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Oliver Wolcott Gibbs.

In Oliver Wolcott Gibbs the chemists of the United States have lost one of their most beloved masters and leaders. Though he obtained his early chemical training in Germany and France, he was an American with all his soul, and though brilliant as a leader in chemistry, he was also a broad-minded American citizen, as evidenced by the part he took in the foundation of the Union League. Dr. Gibbs was president of the National Academy of Sciences and a past-president of the American Association for the Advancement of Science.

Nineteen Hundred and Eight.

After the general industrial depression of the past fifteen months it is to be hoped that in the industrial history of this country the year 1908 will be remembered less on account of this depression, but rather as the year at the end of which resumption of business set in and a new era of industrial activity started. It is certain that the chemical industries of this country have been less affected by the general crisis than other industries. On the other hand the metal industries have suffered very severely from the depression. Perhaps the most interesting feature of the metal market—because evidently of a permanent nature—is the drop of the price of aluminium so that it is now practically in line with copper; this will undoubtedly result in many new applications of aluminium; it is competing not only with copper (especially for electrical purposes), but with tin (tinfoil). In view of the enormous extent to which aluminium is found in nature it is really a common metal and its price has now been adapted to common uses.

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The time of depression has been a suitable one for overhauling the works both in equipment and management, and many metallurgical and chemical works have made the most of this opportunity. Perhaps the most interesting development in modernizing metallurgical works—and a development in which this country may justly rejoice, as it is specifically American, and Europe has not yet risen to its opportunity in this field—is the continued success of the Gayley dry-blast process in its application in several blast-furnace and now also converter plants. The first introduction of this process certainly required American pluck and it has been rewarded by a success beyond all expectations. It is also a peculiar case of metallurgical theory lagging behind practice.

* * *

In electrochemistry the greatest activity has been in electric furnace work. The ferroalloy industry is now established on a large scale in this country as well as in Canada, but as to prices the ferrosilicon market has been in a bad condition for the producers. On electric steel refining we comment in a separate editorial in view of the great importance of this

problem. The carbide industry is steadily progressing along conservative lines; the use of the acetylene-oxygen flame, both for welding and for cutting metals, now attracts deserved attention and seems to have a good future. The carborundum and artificial graphite industries are in a flourishing condition. The silicon industry still suffers from the lack of applications of silicon. Its use as a reducing agent in metallurgical and chemical works seems, however, very promising in many cases and has attracted various inventors. Mr. Betts' proposition on zinc smelting, described under "Recent Metallurgical Patents" in this issue, is interesting in this respect. "Silundum," which is now made commercially in Europe, as described elsewhere in this issue, appears to be in some way related to what is called siloxicon in this country. Deflocculated graphite with its enormous field of applications appears to become the crowning success of Mr. Acheson's wonderful life work. The "monox" industry—which looked so promising a year ago—appears to have been buried, temporarily at least, as a direct result of the financial crisis.

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As to electrolytic processes, nothing of a startling nature is to be reported. The existing plants are doing well. The electrolytic copper refineries have suffered, however, with the whole copper industry from the financial depression. The Townsend cell for making caustic soda and chlorine has proven so successful on a large scale that the Niagara works of the Development & Funding Co. are to be very considerably enlarged. Quite a number of inventors appear to be interested in the use of electrolytic chlorine for detinning tin scrap. With the enormous growth of the tin-can industry, detinning also has grown very considerably, and the new process of chlorine detinning seems to have distinct advantages compared with the older electrolytic detinning process.

* * *

Finally, we may say a few words as to electric discharges through gases. In this class we put together a number of very different reactions. Thus, ordinary air, being essentially a mixture of oxygen and nitrogen, yields very different products when subjected to the silent discharge or the arc discharge. In the former case we have ozone production by the reaction $3O_2 = 2O_3$, in the latter case we get combination of nitrogen with oxygen, and can make nitric acid or nitrates. These reactions are still quite mysterious. In the case of ozone formation, we may be sure to have a specifically electric effect and it seems not to be impossible that it is essentially a photoelectric effect due to ultraviolet light. On the other hand, the formation of nitrogen oxide by the arc discharge had been looked upon for a long while as a purely thermal (electric-furnace) reaction, the arc having no other effect but to produce the required high temperature. It seems now that this is wrong, at least within certain temperature limits; this is encouraging as it means the possibility of getting better outputs than had been thought theoretically possible under the old assumption. Ozone has been used on a large scale in the past in this country for flour bleaching and for producing certain chemical reactions, like the oxidation of iso-eugenol to vanillin, while abroad ozone is also used largely for sterilization of water and air. As to the production of nitric acid from air by arc discharges, the continued success of the Birkeland-Eyde process, with cheap power in Norway, and the apparently even greater success of the Badische Anilin and Soda Fabrik in this field are of chief signficance. This country is more concerned, however, with the other method of fixation of atmospheric nitrogen, namely, in form of calcium cyanamide from carbide, in view of the very large plant which is now being erected at Niagara for this purpose.

Steel Refining in the Electrical Furnace.

It is in the field of steel refining that electrometallurgy is now making the most striking and most important advances. This has not been an evolution of the steel industry from within, but an invasion of the field from without. Not only were the pioneers of this development electrochemical engineers rather than practical steel men, but in view of the skeptical and reluctant attitude of the existing industrial steel plants, these pioneers were forced to erect their own electrical steel works independent of the existing industry. Thus Héroult installed his own steel plant in connection with his aluminium and ferro-alloy works, Kjellin had his own induction furnace steel plant in Sweden, Stassano erected quite large works of his own in Turin, and now Girod is building a special steel plant of a size which should surprise any doubting Thomases, as Dr. Richards says in his description of these works elsewhere in this issue. This was a case of necessity; the attitude of the steel industry made this independent movement necessary to demonstrate to an unwilling public the practicability of the electric furnace process. But it is fortunate that this independent development appears to be about over now and that existing steel works are taking up the electric processes. The electric furnace processes themselves must benefit thereby just as well as the steel industry, and further evolution must be based on sound and healthy coöperation between electric furnace engineers and practical steel men. It cannot be doubted that the Héroult process derived much benefit from the experience gained at the Lindenberg and other old steel works where it has now been in commercial operation for a number of years. It is equally evident that the induction furnace has been changed into a more practical piece of apparatus for steel refining by the commercial evolution at the old Roechling works.

* * *

In the November and December issues of last year we published statistical lists of the electric steel plants now in operation or in course of erection in Europe, and it is interesting to give here a summary of these tables. There are now in operation or course of erection to 19 Héroult furnaces of an aggregate charge capacity of 63,300 kg, and 5 Héroult furnaces the capacity of which has not yet been definitely decided; 11 Stassano furnaces of an aggregate capacity of 16,900 kg; 8 Girod furnaces with a capacity of 34,000 kg; 10 Kjellin induction furnaces with a capacity of 21,500 kg, and 10 Roechling-Rodenhauser modified induction furnaces with a capacity of 29,200 kg. The above figures include 2 Héroult furnaces in this country, the other 22 being abroad. The furnaces of the other types are all in Europe. There are, however, some small Colby induction furnaces in operation in this country; one, chiefly for demonstrating purposes, in Niagara Falls. Two

things are evident from the above figures: First, that electric steel refining is beyond the experimental stage. Second that this country has been lagging in this development behind Europe.

* * *

There is clear evidence, however, now of a change of attitude of the existing steel companies of this country toward the electric furnace. One of the most interesting signs of the time is the testimony just given by Mr. Charles M. Schwab before the Ways and Means Committee in the tariff hearings. We quote from the very full report in *Iron Age*. Mr. Clark asked the question, "whether in your judgment the time has come when these rapid changes in the very expensive business of building these [open-hearth] plants have reached their limit, or whether there is a prospect of improvements being constantly made that will later wipe out that process [open-hearth] and cause the throwing away of these big plants and building new ones?" Mr. Schwab answered, "I think that is true. The open-hearth process has been developing during these past 10 years. It was not believed it would make any material change in the plants except for special things. The demand for quality has made it of such a character that practically all steel must be made by the open-hearth process. We have taken another step in advance which has been developed by the Germans, and that is the electric method of producing steel, which is an advance again over the open-hearth, that I am certain, in the next 10 years, or probably quicker, depending upon the rapidity of the development, will probably make all open hearths practically useless." Clearly Mr. Schwab believes that the future belongs to the electric steel furnace, though we hardly believe that his answer has been correctly understood by the reporter. Nobody who has first-hand knowledge of the electric furnace process believes that the electric furnace is to replace the open hearth. On the contrary, they will work side by side, and the electric furnace will give a new lease of life to the Bessemer converter. What Mr. Schwab probably has said is that all existing open-hearth and Bessemer converter plants will be forced within the next 10 years to install electric furnaces for further refining of the steel from the open-hearth and converter. In this conviction all people who are best informed and best able to judge, agree with Mr. Schwab. This also agrees with the following question and answer from the testimony. Mr. Clark asked: "Well, you are able to get your product out cheaper on account of these?" Mr. Schwab's reply was: "No, we are not. You do not get it cheaper. These processes have not been for the purpose of cheapening the product, but of bettering the quality. Each betterment of quality has added to the cost." Naturally electrically-refined steel will be somewhat more expensive than present steel, but its quality will be very much higher. The consumer will get steel of crucible-steel quality at a cost only slightly exceeding that of ordinary structural steel.

* * *

The reason why the electric steel furnace will surely not displace the open-hearth or the Bessemer converter is that it is considerably cheaper to make steel in two steps in the open-hearth (or in the converter) and refine it in the electric furnace, than to make it in the electric furnace alone in one step. In the latter case the power cost would be prohibitive. Both the open-hearth and the Bessemer converter are excellent metallurgical apparatus, and it would be most foolish not to make the fullest use of what can be done in these apparatus successfully. But the point is that it becomes more and more evident that for many purposes, for instance for railways, better steel is required or would at least be highly desirable than can be made either in the converter or in the open-hearth alone. It is here that the electric refining furnace steps in. If the steel is supplied to the electric furnace in molten form from the open-hearth or converter, the power required is small and the cost of electric refining is small. The net result of the electric refining process is a steel product of very much better quality at a slightly higher cost.

* * *

Naturally as the open-hearth process is simply a preparation for the electric refining process, it will be found preferable to make certain changes from present practice where the open-hearth steel is the final product. Thus Dr. Héroult's method of operation is to extend the open-hearth process to the point when the steel is dephosphorized to the desired degree; it may then be highly oxidized, but this does not matter, as the steel is to be treated now in the electric furnace. There the steel is deoxidized (which is possible on account of the reducing atmosphere of the furnace), the sulphur is reduced and the steel is recarbonized to the desired degree. The desulphurization accompanies the deoxidization and the remarkable success of desulphurization is due to the formation of calcium sulphide, which is a specific electric-furnace reaction. In this way it is possible to get a final steel product in which the sulphur and phosphorus are reduced to any desired degree. Of course, the electric power and the attendance cost some money, but on account of the possibility of using large units (entirely different from crucible steel practice) the cost of attendance per unit of output is low, and if the steel comes in molten form into the electric furnace, the power required is small. However, the easy removal of phosphorus and sulphur are not the only advantages of the process. Another important advantage is the great uniformity and homogeneity of the product, its freedom from oxides, gases, or slag. This fact will make electric refining highly desirable even in cases where steel is made from low-phosphorus and low-sulphur pig in the open-hearth. Cuban mines have placed such pig iron at the disposal of a few fortunate steel companies. Of course, in such cases the electric furnace treatment will be less expensive. In any case the cost depends on the reactions desired and the time needed for the reactions.

* * *

Finally it may not be amiss to refer briefly here to two special developments in the electrometallurgy of steel. One is the Lash steel process, fully covered by the paper of Mr. FitzGerald in our December issue; this process appears to bring the problem of making steel directly from ore nearer its solution in a special case. The other development is the annealing and tempering furnace, using a fused bath in which the article to be treated is placed. It has been very successful abroad and is now being introduced in this country. The nicety of temperature adjustment and the almost perfect constancy of the temperature throughout the whole bath are indeed remarkable. In the whole the outlook of the electrometallurgy of steel is exceedingly encouraging. While the advance has been made chiefly abroad in the past, there is no doubt that when the

steel men of this country enter the procession with their characteristic push, they will soon be leading the world.

Electric Smelting of Iron Ore.

While in general the electric furnace for reduction of iron ore cannot compete commercially with the blast furnace, for reasons which we have pointed out repeatedly in these columns, local conditions may make iron ore reduction in the electric furnace practicable at special places—namely, wherever conditions are favorable to the production of cheap electric power and unfavorable to blast furnace practice. In the latter respect lack of coke may be the determining factor, if only charcoal or peat-coke is available, both being well suited for reducing agents in the electric furnace. There are localities which answer these requirements; in order not to go too far away, we may mention California and sections of Canada. The electric furnace for smelting iron ore has, therefore, decidedly more than a merely scientific interest, and Mr. Joh. Harden's able discussion of the subject, which will be found elsewhere in this issue, will prove interesting. Mr. Harden's point of view is to compare directly electric-furnace and blast-furnace working; he compares the cost if the reaction is the same in both cases. We may, however, also look at the matter in a different way and ask whether it is not possible to so change the method of working as to get in the electric furnace a reaction somewhat different from that in the blast furnace.

* * *

That there is some wisdom in putting the question in this way follows from the kindred problems of steel rening. We can use the electric furnace simply as a melting apparatus; then the reaction in the electric steel furnace is essentially the same as in the crucible process and the superiority of the electric furnace is simply due to the possibility of using large units with a reduced cost of apparatus and attendance. But we can go further. As has often been explained in this journal, we can use the electric furnace for refining steel by means of reactions which are impossible with the open-hearth and the Bessemer converter; and in the last analysis these possibilities will be found to be due to two causes; first, the higher temperature available in the electric furnace, and second, the possibility of carrying out the reactions in a neutral or reducing atmosphere, in absolute contradistinction to the oxidizing atmosphere of ordinary metallurgical practice. To make the utmost of these possibilities and not simply to imitate crucible steel practice in electric furnaces must be the aim of those who are developing electric steel processes.

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As to reduction of iron from ore in the electric furnace, the chief difference between the chemical reactions in the blast furnace and in the electric furnace lies in the fact that in the latter there is no oxygen from the blast and the carbon is simply reducing agent. Theoretically less than one-third as much carbon is required in the electric furnace as in the blast furnace. This has important consequences. The blast furnace is necessarily a huge gas producer; that is, in the blast furnace it is impossible to burn the carbon to dioxide, since any dioxide formed, when coming in contact with free carbon, will form again carbon monoxide. For this reason blast-furnace gas *must* contain considerable amounts of monoxide. The electric furnace is not subject to the same limitations. It would be possible by using a sufficient amount of carbon to so run the electric furnace as to get a gas as rich in monoxide as blast-furnace gas and, of course, this gas could be used just as well for running gas engines. But it would be wrong policy to do this. The electric furnace process will be the more efficient the more complete the oxidation of carbon to carbon dioxide within the furnace itself. It is therefore very important to reduce the quantity of carbon to a minimum. On this account and on account of the higher temperature obtainable and its more complete control, the electric furnace offers possibilities which the blast furnace has not. The Sault Ste. Marie experiments of the Canadian Government, a few years ago, have proven the possibility of elimination of sulphur, of complete control of silicon, of smelting titaniferous ores, etc. But there is still room for much purely chemical research, and when this is undertaken the utmost attention should be paid to gas analysis, which has not been done in the past. Further, there is still much to be done in evolving a proper furnace design suited for this particular purpose. In this respect we hope that Dr. Haanel's present trip to Sweden to examine for the Canadian Government the electric furnace of Messrs. Gronwall, Lindblad and Stalhane will yield interesting and valuable information.

The Situation in the Iron and Steel Industry.

The American iron trade has shown a conformity, in prices and production, with the 20-year cycle in which trade generally has been discovered to run. That 20-year cycle in general business found its nodal points in the panic years 1873 and 1893, and the iron trade conformed. The year 1873 did not, it is true, show diminished pig iron production, but the next three years showed successively declining production, and it was not until two additional years had elapsed that the production of 1873 was passed. The year 1893 itself showed diminished production. Both 1873 and 1893 were years of sharply declining prices. Each of these panic years was followed by a period of several years of depression. We spoke of these panic years as nodal points; at first glance one might think that a panic year is the last that should be selected as a nodal point—a point of rest—because panic suggests excitement, but the idea is that these years were years of transition from activity to quiet. A citation of railroad statistics will suffice: the year 1873 was the third successive year of decreased railroad building, but in the two following years the new mileage successively decreased further; the year 1893 was the fourth year (barring a negligible increase in 1892) of successive decrease in railroad building, but in the three following years railroad building continued to decrease These panic years lay midway in a decline in activity.

* * *

A review of the movement of the iron trade year by year, since 1893, would show conclusively that, barring the most minor discrepancies, the course of the iron trade has duplicated the course it followed after 1873. The conformity is startling, but it would be tiresome to adduce the historical proofs in this connection. The swings in the iron trade since 1893, then, are not to be taken as haphazard occurrences, since they were a duplication of what had taken place once before, 20 years earlier. Another circumstance encourages the inference that

there is a law underneath these workings. After 1873 and 1893 there was a period of stagnation, lasting well through 1878 and 1898. In 1879 and 1899 there occurred a wonderful boom. Prices soared to wholly unexpected heights, and productive capacity was strained to the utmost. As a result, the movement played out quickly, prices breaking sharply in 1880 and 1900, afterwards recovering more slowly to high points in 1882 and 1902. In 1882 a decline started early in the year, while in 1902 the decline began later in the year. In each case the decline was much more gradual than the preceding decline, and the recovery which ensued was gradual, but very substantial. The recovery, in the case of the more recent period, led us into that period of remarkable sustained activity, 1905-6-7. The point of particular interest in this movement is that the swings have grown less and less violent, and have covered longer and longer periods of time. The 1899 boom was short; the 1902 boom was longer; the three-year period 1905-6-7, was too long, and its business was conducted in too orderly a manner, to permit it to be considered a boom at all; it had the substance of several booms combined, without their intermediate periods of reaction. There is reason to hope that the panic of October, 1907, was not a great panic like those of 1873 and 1893, because it fails to show the periodicity. There is reason to hope that it was not so because the iron trade was establishing a tendency toward a longer and longer swing. There is reason to believe so, because the elements of panic, of unreasoning fear, have been clearly observed to be absent from the trade. Were 1907 a replica of 1873 and 1893 it would be proper to expect several years of declining prices and diminishing production, but the signs of the year 1908 do not so indicate.

* * *

As to production, it is to be observed that pig iron production in the second half of 1908 has exceeded that of the first half by about 2,000,000 tons, or by almost 30 per cent, and that this has been the case despite the fact that much work financed and undertaken before the October panic was continued into 1908. The leading structural interests worked for months in this past year almost wholly on contracts thus furnished. Had it not been for this and other work which so lapped over, the first half of 1908 would have shown still smaller production and the second half would have shown a greater appearance of recovery by the emphasis given to the contrast. It is obvious that the trade has been steadily jogging along the road of recovery. We have compared second half production with first half; the comparison can be taken in detail: June was a month of very small production, and each following month has shown a successive increase in tonnage. That there has been steady progress is certain, and it is along the road of recovery. That the road can be traveled, in the present manner, until the point of previous record production is reached, is not so certain, while that it can pass this point, and attain a new tonnage rate, conforming to the increased capacity which is coming into being, is still less certain.

* * *

Let us review our measurements: pig iron production has been as follows:

Year.	Gross tons.
1901	15,878,354
1902	17,821,307
1903	18,009,252
1904	16,497,033
1905	22,992,380
1906	25,307,191
1907	25,781,361

A little scrutiny shows that there has been an average gain of 2,000,000 tons a year. It was just so from 1901 to 1902; 1903 ended with a slump, and 1904 contributed further to the backset, but 1905 emerged with a tonnage sufficient to make up the expected gain of 2,000,000 tons each year, barring the loss of a single million, and 1906 contributed its 2,000,000 tons, with a trifle to spare. It was easily observed that had the production rate of October, 1907, been continued through that year there would have been the regular gain of 2,000,000 tons over the preceding year. The progression has been rudely interrupted, and the year 1908 will show an output of only about 15,850,000 tons, a decline of 9,000,000 tons from the actual production of the calendar year 1907, a decline of 11,500,000 tons from the gait which 1907 maintained during its first 10 months, and a deficiency of more than 12,000,000 tons from the capacity which was in full operative condition. It is, finally, 16,000,000 tons less than the prospective capacity, through plants now almost completed and which would have been completed before this had work been pushed. Evidently the certainty that the iron trade is now steadily moving along the road of recovery cannot promise that the pace can be maintained until the goal of full activity has been reached.

* * *

During the period of intense activity which culminated in October, 1907, with a pig iron production rate exceeding 28,000,000 tons a year the adage was adopted, "Steady prices make steady demand," but there was evidence that the function of steady prices was really that of leading to anticipation of wants, because waiting a while did not promise the lower prices which in the past usually followed periods of heavy demand. When the reaction came, it became evident that wants had been anticipated, and the fall was the more sudden. The iron and steel industry has made great strides in processes and devices in these years. The cost of making steel, measured not by wage rates, changing in their own amount and in the quantity of service rendered for them, but by actual expenditure of fuel and mental and manual energy, has been greatly decreased. Through influences without the trade, and to a great extent through influences within the trade, a realization upon these achievements through the inviting of increased demand with lower prices has been denied to the industry, although it stands in need of this assistance. If there is not an improvement in this respect, a retarding influence is likely to be felt more and more, as the industry progresses on its road toward the engagement of the full tonnage capacity. The plants are in position to make new records of efficiency and show new low records of cost, if the facilities are afforded them. Whether that tonnage demand can be gained through the medium of lower prices is doubted by many good judges of the trade, but considering the efficiency the individual plants would show if run at full capacity, and the enormous capacity which is in existence, or on the verge of completion, compared with the present measure of demand, it may at least be suggested that the question still deserves serious consideration.

International Congress of Applied Chemistry in London.

The seventh International Congress of Applied Chemistry will be held in London from May 27 to June 2, 1909. The president of honor is Sir Henry Roscoe; the active president, Sir William Ramsey, Mr. Macnab is general secretary, and Messrs. Thomas Tyrer and C. Whitman are treasurers. Dr. Harvey W. Wiley, of Washington, D. C., has been appointed the chairman of the American committee.

The congress is divided into the following sections and subsections. The American chairmen of the sub-committees who will take charge of all papers and matters relating to the sections to which they are assigned, are as follows: (1) Analytical Chemistry, Charles Baskerville, College of the City of New York; (2) Inorganic Chemistry and Allied Industries, J. D. Pennock, Solvay Process Co., Syracuse, N. Y.; (3a) Metallurgy and Mining, John Hays Hammond, 71 Broadway, New York City; (3b) Explosives, Charles E. Munroe, George Washington University, Washington, D. C.; (4a) Organic Products, William McMurtrie, 480 Park Avenue, New York City; (4b) Coloring Substances and Their Uses, Bernard C. Hesse, 90 William Street, New York City; (5) Industry and Chemistry of Sugar, C. A. Browne, 80 South Street, New York City; (6a) Starch Industry, T. B. Wagner, Heyworth Building, Chicago, Ill.; (6b) Fermentation, Francis Wyatt, 402 West Twenty-third Street, New York City; (7) Agricultural Chemistry, C. G. Hopkins, University of Illinois, Urbana, Ill.; (8a) Hygiene and Medical Chemistry, Reid Hunt, United States Public Health and Marine Hospital Service, Washington, D. C.; (8b) Pharmaceutical Chemistry, Joseph P. Remington, 1832 Pine Street, Philadelphia, Pa.; (8c) Bromatology, W. D. Bigelow, Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.; (9) Photochemistry, L. H. Baekeland, Yonkers, N. Y.; (10) Electrochemistry and Physical Chemistry, W. D. Bancroft, 7 East Avenue, Ithaca, N. Y.; (11) Law, Poltical Economics and Legislation, with Reference to Chemical Industries, Charles B. Dudley, Altoona, Pa.

All who are interested in promoting the applications of chemistry are eligible for membership in the congress. The price of membership is £1 for men and 15s. for women. American chemists intending to become members should send their check for $5 either to the chairman of one of the sections or direct to the chairman of the American committee at Washington, who will transmit same to the proper official in London.

Those intending to present papers should write to the chairman of the section to which the paper belongs. Papers should be neatly typewritten on thin paper and be in the hands of the chairman of the American committee not later than April 1, 1909, in order to be forwarded to London for translating and printing.

Those who cannot attend will be amply rewarded for membership by receiving the publications, which will be in several large volumes and which will contain the latest ideas and discoveries connected with the progress of applied chemistry. The *Proceedings* of the fifth congress consisted of four volumes containing articles by experts upon all branches of applied chemistry. The *Proceedings* of the sixth congress numbered seven large volumes. The *Proceedings* of the next London congress will no doubt surpass all previous ones in the quality and quantity.

Pittsburgh Meeting American Institute of Chemical Engineers.

The first annual meeting of the American Institute of Chemical Engineers will be held at Pittsburgh, Pa., on Dec. 28 and 29, 1908. All the sessions will be held at the Carnegie Technical Schools. Hotel headquarters are at the Hotel Schenley.

The first session will be held on Monday morning, Dec. 28, beginning at 9:30. The program of the papers to be presented at this session is as follows:

"Steam Power Plant Economics from the Standpoint of the Chemical Engineer," by William M. Booth.

"Technical Coal Analysis," by Edward Gudeman.

"The Chemical Aspect of Impurities which Cause Scale and Corrosion of Steam Boilers," by J. C. William Greth.

"Testing and Performance of Steam Generating Apparatus," by A Bement.

"The Examination of Flue Gases in Boiler Tests," by H. August Hunicke.

"The Utilization of Low-Grade Fuels in the United States" (illustrated by photographs and samples of peat-coke and by-products produced by the Ziegler process for coking peat and ignite), by O. K. Zwingerberger.

"Producer-Gas Installations," by Ernest Schmatolla.

"Work of the United States Government Fuel-Testing Plant at Denver, Col.," by A. W. Belden.

In the afternoon an excursion will be made to the Duquesne plant of the Carnegie Steel Co. In the evening dinner will be taken at the Hotel Schenley, after which the business meeting will be held, followed by the presidential address of Dr. Samuel P. Sadtler and an illustrated lecture by Mr. Richard K. Meade on the heating of industrial furnaces with pulverized fuel.

The program of the papers to be presented at the Tuesday morning session is as follows:

"Modern Electrical Resistance Pyrometry," by Edwin T. Northrup.

"Chemical Specifications for Sulphite Pulp," by J. A. DeCew.

"An Apparatus for Testing Liquified Ammonia Gas," by F. W. Frerichs.

"The Sanitary Condition of the Southern End of Lake Michigan," by Herbert Brewster.

"Cement Manufacturing Methods," by J. G. Dean.

"Some Experiments with the Ferric Iron Contact Method of Making Sulphuric Acid from Smelter Fumes," by Thorn Smith.

In the evening of Tuesday, Mr. William M. Grosvenor will lecture on "Dryer Calculations and Dryer Design."

For Tuesday afternoon several excursions will be arranged. Permission has been obtained to visit the following plants, the date and hour of each excursion to be announced at the meeting:

Homestead and Duquesne plants of the Carnegie Steel Co.

By-product coke works of Carnegie Steel Co., at South Sharon, Pa.

Phoenix Glass Co.'s works at Monoca, Pa.

Pittsburgh Gas & Coke Co.'s by-product works at Glassport.

Coke plant at Uniontown of the H. C. Frick Coke Co.

Westinghouse Machine Co.

The laboratories and testing departments of the Carnegie Technical Schools will be open for inspection.

In connection with the meeting an exhibition will be made of chemical engineering apparatus and of drawings and photographs of such apparatus and installations. Among the exhibitors are: Cleveland Bronze & Brass Works, Davis Bournonville Co., Didier-March Co., H. W. Dopp Co., Fuller Engineering Co., Leeds & Northrup Co., George M. Newhall Engineering Co., Schutte & Koerting, Edward R. Taylor, Vulcan Iron Works, and the Zaremba Co.

Iron and Steel Institute.

The council of the Iron and Steel Institute have awarded the Bessemer Gold Medal to Mr. Alexandre Pourcel, an eminent French metallurgist. The Bessemer gold medal is awarded annually for services to metallurgy, and it is for his investigations in the manufacture of ferromanganese and for his work on the thermal reactions involved in the manufacture of iron and steel that Mr. Pourcel, who was elected a member of the

Iron and Steel Institute in 1879, now becomes the recipient.

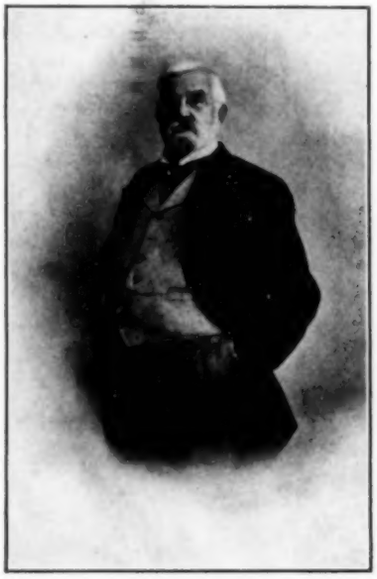
The council have appointed Mr. G. C. Lloyd to the vacancy occasioned by the death of Mr. Bennett H. Brough, secretary of the institute. Mr. Lloyd is at present secretary of the (Brit.) Institution of Electrical Engineers, having been appointed in 1904. In 1900 he was appointed assistant to Mr. Brough, at the Iron and Steel Institute, a position he held until his appointment to the Electrical Engineers.

The council have at the same time offered the assistant secretaryship to Mr. L. P. Sidney, who was appointed as Mr. Brough's assistant in succession to Mr. Lloyd in 1904. Hitherto there has been no formal office of this description.

William M. Habirshaw.

Since the late Mr. Habirshaw has been truly called a pioneer of the modern generation of chemical engineers, the fitting tribute paid to his life work, at the recent annual meeting of the Chemists' Club by a special committee, consisting of Dr. T. J. Parker, Dr. C. F. Chandler and Dr. G. A. Goldschmidt, should prove a source of inspiration.

The sketch of the life of Mr. Habirshaw from the pen of Dr. T. J. PARKER is herewith reproduced:



WM. M. HABIRSHAW.

"Wm. Martin Habirshaw was born in February, 1835, at 197 William Street, New York City. His early education was obtained in New York and later in Europe, but Mr. Habirshaw was essentially a self-educated man. Leaving the U. S. Navy, where he had served as an engineer previous to 1873, he opened a laboratory for commercial analysis and consultation at 36 New Street, and later removed to Fulton Street.

"How long previous to the year named this laboratory had been in operation we cannot learn, but it had been there for several years. This laboratory was maintained until 1876 or 1877, during which period he did the bulk of the commercial analyses required by the chemical industry to be obtained from independent analyses. Products such as bleaching power, soda ash and wood pulp were analyzed, and in fact his work embraced the whole range of commercial analyses as then known.

"He was a Fellow of the Royal Society, charter member of the American Chemical Society, a member of the Society of Chemical Industry and the Chemical Society of London, and an authorized chemist of the Produce Exchange. His service to the iron industry was of great value, and many of the improvements in its processes are due to him. He also rendered great service to the sugar industry and fertilizer chemistry. Mr. Habirshaw was probably the first of those whom we would now call a Chemical Engineer.

"Among other industries he gave his attention to was manufacturing alkali by the soda-ammonia process, and he had intended starting such an industry in this country on a large scale, but the capitalists interested with him had not sufficient faith in the future of the industry in this country in competition with the foreign product.

"Mr. Habirshaw also devoted a great deal of his time to the application of electricity to technology, and the requirements of such application. In this connection he produced insulation compounds which have been in continued use for many years.

"In 1886 he organized the India Rubber & Gutta Percha Insulating Co., of which he became president and general manager, with a factory at Twenty-fourth Street and Eleventh Avenue, New York City. In this factory was manufactured the compounds spoken of. Here also he devised many improvements in the machinery for the application of his compounds to electrical conductors.

"About 1890 this business was moved to Glenwood, in the City of Yonkers, where it continued to grow and is at present in most successful operation, its name having been changed to the Habirshaw Wire Co., on January 1 last.

"Mr. Habirshaw retained to the end his large interests in the company and gave it much of his personal attention. For several years his health had been failing and he was a great sufferer. Knowing that his active career was growing to a close, he organized and trained a corps of men who should be ready at any time to assume the work which he had so successfully directed since the organization of the company.

"Mr. Habirshaw was a man of delightful personality. He was fortunate in drawing about him men prominent in all walks of life, scientific, literary, artistic, army and navy men and financiers. Not only did Mr. Habirshaw take a keen delight in the practice of chemistry, but also in advancing the interests of chemists. He was never called on to assist a brother chemist, either financially or with advice, that he did not respond most generously. The profession of chemistry has suffered a great loss in his demise."

The Iron and Steel Market.

The closing month of the year has been a quiet one as regards market transactions. A dull December is normal in the trade, while the past three Decembers have been exceptions to the rule. In 1905 and 1906 the market was under such buying pressure that there was no opportunity for the usual lull, while in 1907 the October panic had created such a disinclination to act that no special dullness in December was noticeable. Consumers of pig iron and finished products wish to reduce their obligations and stocks as much as possible against the closing of their books at the end of the year.

There has been no change in the attitude of producers as to the future of the trade, a feeling of confidence prevailing that 1909 has better things in store for the iron and steel trade than 1908 has afforded. No sudden increase in demand is looked for, but a steady progress toward a higher plane of activity is expected. The railroads expected to increase their purchases gradually rather than suddenly. Such an increase would reflect an increase in the general business activity of the country, making increased traffic and larger earnings.

While there has been little market activity in the month, production has been well maintained. Steel-making pig iron is hardly likely to show any decrease, an increase being more probable, and it is going into consumption as usual. There may be some accumulation of foundry iron in furnace yards, but if so, this reflects no more than the desire of melters to reduce their stocks to the minimum. The demand for steel products has run chiefly to the lighter lines, wire products, sheets, tin plate and merchant mill products, the tonnage of these lines constituting an unusually large percentage of the

total steel output. The consumption of these lines is as large at this season of the year as at other seasons. Tin plate has just passed out of its dull period, the mills now running on plates for the salmon industry and stocking other consumers against the spring rush.

There are no immediate prospects of any changes in prices. There was a substantial advance in pig iron late in October and during November, and the probabilities seem to be that the advanced prices will be held, for the time, without further change. In finished steel products there has been no movement for any advances, while there is no particular reason to expect any decline. The leading producers are committed to the maintenance of prices and do not seem to expect any change except in the untoward event of some individuals changing their views and acting independently.

PIG IRON.

The Eastern pig iron market has advanced slightly since last report, while Chicago, Alabama and Pittsburgh present no change in prices. No. 2X foundry, delivered Philadelphia, is quotable 25 cents higher than at last report, at $17.25 to $17.50. Some Southern furnaces are still willing to sell at $13, Birmingham, for first quarter or first half, although many producers adhere to $13.50 for the later delivery. Chicago district furnaces continue to quote $17, a price which is more attractive than formerly, on account of the advance in Southern iron in November. The valley furnaces are quoting former prices, except on Bessemer, which seems to be established on a basis of $16.50, against $16 quoted in our last report. Foundry iron is $15.50 to $16, valley, basic $15.50, and forge $14.25 to $14.50.

BILLETS AND SHEET BARS.

The market has been very quiet, but shipments have been well maintained. Prices are firm, except that in the East there is still occasional shading on billets, concessions generally amounting only to a fraction of a dollar. The regular market is $25 on billets and $27.50 on sheet bars, with certain concessions on freights.

FINISHED MATERIAL.

There has been further firming up in prices, and the whole list is now pretty well observed, there being occasional slight concessions in one or two lines. Light rails are sold at $23 to $24 by some of the rerolling mills, the official price of mills making light rails from new steel being $25. Official prices are as follows, f.o.b. Pittsburgh, except in the case of rails, which are f.o.b. mill:

Standard rails, $28 for Bessemer; $30 for open-hearth.

Light rails, $25.

Plates, 1.60 cents for tank quality.

Shapes, 1.60 cents for beams and channels, 15 in. and under, angles and zees.

Steel bars, 1.40 cents; iron bars, 1.50 cents, delivered Pittsburgh; 1.50 cents delivered Chicago.

Plain wire, 1.80 cents; wire nails, $1.95.

Sheets, 2.45 cents, net, for black; 3.50 cents, net, for galvanized, 28 gage.

Tin plates, $3.65, net, for 100-lb. cokes.

A 20,000-H.P. Twin Tandem Compound Reversing Blooming Mill Engine.

On Nov. 12, at 11:30 a. m., steam was turned on for the first time in an engine of the above type in the 40-in. blooming mill of the Carnegie Steel Co.'s Duquesne Steel Works. At 1:30 p. m., two hours later, the mill was put in operation, and up to the time of an inspection, Dec. 18, by members of the Engineers' Society of Western Pennsylvania, the mill had not lost five minutes on account of the engine.

The engine was built by Mackintosh, Hemphill & Co., which at the same time carried through a companion engine, intended for the new Aliquippa plant of the Jones & Laughlin Steel Co. The engine is unusually massive, weighing about 2,260,000 lb. It embraces a number of novel features, particularly in the valve mechanism and in the accessibility of parts.

The engines are 44 and 70 by 60 and are designed to run at 100 to 150 r.p.m., developing 20,000 hp. The complete reversal can be accomplished in 15 seconds. During the inspection a copper cent stood on edge on the bedplate. While the specifications were quite rigid, the builders used about 400,000 lb. more metal than was called for, and, considering the engine's remarkable success, are well satisfied that they did so.

The mill has been running somewhat slack, blooming the 6000-lb. ingots in about 2½ minutes. When steel is available from the new open-hearth furnaces at Duquesne, now nearing completion, the time will be decreased to two minutes, giving the mill an output of about 80 tons an hour, or nearly 2000 tons in 24 hours.

CORRESPONDENCE.

Heat Conduction Through Furnace Walls.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—The paper by Mr. Carl Hering on the conduction of heat through furnace walls, published in your December issue, is exceedingly interesting and should be appreciated as an important first step toward the solution of the problem to calculate in advance the heat loss through the walls of a furnace. Mr. Hering's formulas permit the exact calculation of the heat losses through the walls of usual construction under the following assumptions: Firstly, that the heat conductivity of the walls is known (more exactly, as function of the temperature); secondly, that the temperatures of the inside surface and of the outside surface of the furnace walls are known.

Under present conditions, as a result of the existing lack of data, Mr. Hering's formulas can hardly be expected to be applicable for exactly predetermining the heat loss of a new type of furnace. But they should be useful in the hands of metallurgists for comparative estimates; for instance, if the behavior of a furnace is known and this is to be doubled in capacity, how much must we increase the furnace walls? Such questions may be answered on the basis of Mr. Hering's diagrams.

As to the first assumption, stated above, I was struck by the reference to Peclet's old work. It is very little known. Why not republish his figures?

As to the second point, it should be emphasized that the two temperatures in Mr. Hering's formulas are the temperatures of the inside and the outside wall surfaces themselves, not the temperature of the charge inside and of the air outside in contact with the walls. For there may be no thermal equilibrium at the contact surface. If we cool with running water we know there is a sudden drop of temperature at the surface and this drop depends on the speed of the water (see, for instance, J. W. Richards, your Vol. IV, p. 99, reprinted in the first volume of his Metallurgical Calculations). In the analogous electrical problem (conduction of an electric current through the wall) we have here not only the ohmic drop of voltage due to resistance, but an e.m.f. at the surface.

This brings us to the very important practical case of water-jacketed furnaces. Here the chilled slag, immediately formed on the walls, forms a natural refractory lining. When water-jacketed furnaces were introduced much fear was expressed that the heat losses would be prohibitive. But Mr. Herreshoff published long ago some tests on the amount of heat loss in feed water, and proved that only 5 per cent of the total heat was lost in water from jacket. Undoubtedly Mr. Hering's explanation is correct that this is due to the low thermal conductivity of the chilled slag. But it would seem highly impracticable to try to calculate in this complex case the heat loss by such formulas as Mr. Hering's. We must rely on empirical rules, although an endeavor should be made to place them on a more scientific, that is, rational, basis.

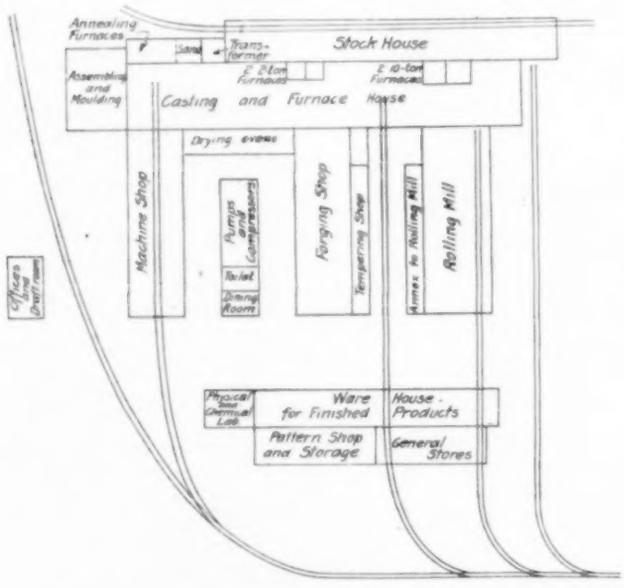
Denver, Colo. Metallurgical Engineer.

The Largest Electric Steel Works.

BY JOSEPH W. RICHARDS.

Mr. Paul Girod, a native of Freyburg, Switzerland, started ten years ago at Albertville in the Savoy, not far from Mont Blanc, with one man as assistant and a 25 horse-power dynamo, to utilize the power available in *"houille blanche"* (white coal, i. e., snow) for making ferro-alloys. This business has been transferred to Ugine (Savoy), where it has grown to splendid proportions, using up to 9,000 horse-power in seasons of high water. These products are now exported to all parts of the world. (See the article of Dr. R. S. Hutton, ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, 1907, Vol. V, page 9.)

More recently Mr. Girod has devised the Girod electric steel furnace, and has begun to manufacture steel. His furnace and its method of operation have been already described in this journal. (See our Vol. VI, pages 428 and 516, 1908.) He is now so sure of the absolute control which the electric furnace gives as to quality of steel, uniformity of working and cheapness as compared with the crucible process, that the Société Anonyme Electrométallurgique Procédés Paul Girod, with 5,000,000 francs capital is now building at Ugine, in Savoy, a



PLAN OF ELECTRIC STEEL WORKS.

plant which may be regarded as the largest, most complete and altogether the pioneer electric steel plant of this new dispensation in the metallurgy of steel. The scale on which this plant has been designed will certainly surprise any doubting Thomases who have hitherto refused to "enthuse" over this new industry.

Here, as elsewhere, the industry has not been a development by steel workers, not an evolution from within the steel industry, but an invasion of the field from without, by technologists who had everything to learn about the making of steel. Stassano at Turin was a captain in the artillery, Héroult was a chemist busied principally with aluminium, Colby was a platinum refiner, Kjellin an electrical engineer, and Girod was a chemist who probably never saw the inside of a steel works until quite recently. His associates are chemists, engineers and machinists, but hardly any can be called "practical steel men" aside from their connection with the Girod plant. However, they are creating a new metallurgy of high-quality steel. By using a finely equipped chemical laboratory, fully planned mechanical testing plant, and with minds fully receptive of new ideas and unfettered by old traditions, they stand a very good chance to introduce new life into the manufacture of fine and special steels. Here is the making of history in the metallurgy of steel, and the world which uses fine steels will profit immensely by their enterprise.

The new plant is expected to be in operation in March, 1909. Houses for the workmen are being built, 22,000 horse-power of water fall is being harnessed, and in a few months a beautiful Alpine valley surrounded by snow-clad mountains will be the seat of an important and new type of steel industry. The annexed plan and description will give an idea of the magnitude of this undertaking.

Stock House.—For receipt and storage of steel scrap and furnace material of all kinds. It is 17.5 by 140 meters (58 by 460 feet) and equipped with overhead traveling cranes and magnetic lifting apparatus.

Furnace and Casting House.—21.5 by 165 meters (70 by 550 feet), provided with two traveling cranes of 2 tons capacity and two of 15 tons. Contains at present two 2-ton furnaces and two 10-ton furnaces. The latter will be normally operated at from 8 to 12 tons charge using current at 60 volts and 32,000 amperes. The normal output of these is reckoned at 50 tons per day, but there is room and corresponding works capacity for four times as many furnaces, and an eventual output of 200 tons per day. The smaller furnaces are intended particularly for making special and high-price steels, the larger ones for carbon and nickel steels.

Transformer Building.—It is 10 by 10 meters (33 by 33 feet) in size, the current being transmitted at 45,000 volts over 40 kilometers (24 miles) from St. Gervais. We have not discussed with Mr. Girod the reasons for placing it at the point indicated, but it appears to us unnecessarily distant from the furnaces, entailing large expenses for the conductors. The large furnaces are nearly 300 feet from the transformers, and it would appear as if several small transformer stations in close proximity to each of the furnaces would have been more economical of aluminium and of power.

Sand Storage House.—10 by 10 meters (33 by 33 feet).

Drying-Oven House.—15 by 45 meters (50 by 150 feet). For core ovens and drying moulds.

Assembly Shop.—20 by 31.5 meters (67 by 105 feet). For assembling of moulds, making of cores, moulds, etc.

Annealing Shop.—10 by 20 meters (33 by 67 feet). Containing annealing furnaces for treating castings.

Machine Shop.—21.5 by 75 meters (70 by 250 feet). For lathes, planers and like machinery for finishing castings.

Forging Department.—21.5 by 75 meters (70 by 250 feet). Will contain a 600-ton hydraulic press for rough forging of 10-ton ingots, and eight power hammers of 3,000, 1,000, 500, 300, 200, 100, 75 and 50 kilograms respectively, driven by compressed air.

Tempering Shop.—As an annex to the forging shop 15 by 60 meters (50 by 200 feet).

Rolling Mill.—27.5 by 75 meters (90 by 250 feet). Will contain one train of 525 millimeters (20 inches) and one of 305 millimeters (12 inches). They will be electrically driven by an 800 horse-power, three-phase motor, using current at 2,500 volts.

Annex to Rolling Mill.—15 by 60 meters (50 by 200 feet), for storage of rolls, machinery, etc.

Pump and Compressor Building.—15 by 35 meters (50 by 115 feet). Will contain two compressors handling each 60 cubic meters (2,000 cubic feet) of air per minute and compressing to 5 atmospheres, one handling 20 cubic meters (700 cubic feet) per minute compressing to 5 atmospheres, and one of 20 cubic meters compressing to 7 atmospheres. These are all electrically driven. There will also be two rotary converters of 300 horse-power each, transforming the 2,500-volt, 50-period, three-phase currents into direct current of 500 volts for use by the electric railway, traveling cranes, and other machinery.

Warehouse for Finished Products.—15 by 100 meters (50 by 325 feet). This is made particularly large because of the variety of products intended to be made, and also because at

seasons of high water power the works will accumulate stock to carry it over seasons of small power.

Pattern Warehouse.—15 by 50 meters (50 by 160 feet). Rather distant from the foundry.

General Stores.—15 by 50 meters (50 by 160 feet).

Physical and Chemical Laboratory.—15 by 20 meters (50 by 65 feet), fitted in basement with the most modern machines for mechanical tests, and on the first and second floors with a first-class chemical laboratory.

Wash Room.—10 by 15 meters (33 by 50 feet) for dressing, washing, bathing, fitted up with modern sanitary appliances.

Dining Room.—10 by 15 meters (33 by 50 feet), with kitchen. For use of officers and workmen.

Office and Drafting Room.—A 2-story building, 15 by 25 meters (50 by 80 feet), of ornamental stone and brick.

Railway.—The plant is served by numerous branches of railway, as shown, of standard gauge, operated by overhead trolley, as far as the works is concerned, but accessible to steam locomotives. The plant is 98 kilometers (59 miles) from Geneva, 165 kilometers (99 miles) from Lyons, 390 kilometers (230 miles) from Marseilles and 470 kilometers (280 miles) from Toulon (French naval station). It is reached from Geneva *via* Annecy, from Marseilles *via* Grenoble, from Paris or Turin *via* St. Pierre d'Albigny on the Mount Cenis Tunnel route. The plant is expected to be in full operation by March, and we understand that visitors will be cordially welcomed.

Experiments on Melting in the Induction Furnace.

By F. A. J. FitzGerald.

A casual consideration of the induction furnace suggests the conclusion that it would prove but an inefficient apparatus for the conversion of electrical energy into heat. The metal contained in the annular crucible presents a large surface by which heat can be carried off by radiation and conduction, as compared with furnaces of other types, and thus the question may be asked: "Why not give up the induction principle altogether?"[1]

There are three methods by which a metal to be melted in a furnace may be heated electrically:

(1) By heating a suitable resistor with an electric current or by forming an arc and then heating the metal *by radiation.*

(2) By heating a substance in contact with the metal either by an arc or by passing the current through it and then transmitting the heat into the metal *by conduction.*

(3) By passing the heating current through the metal.

When the metal is heated by radiation from a hot body the rate at which the heat is conveyed thereto reaches a maximum when the temperature of a part of the furnace reaches a maximum and the rate of heating varies with the difference in temperature between the hottest places and the metal.

Similarly, when the heat is transmitted by conduction the maximum rate of heating is attained when the highest temperature is reached at the place of generation of heat.

[1] Electrochemical and Metallurgical Industry, Vol. VI, No. 11, p. 439.

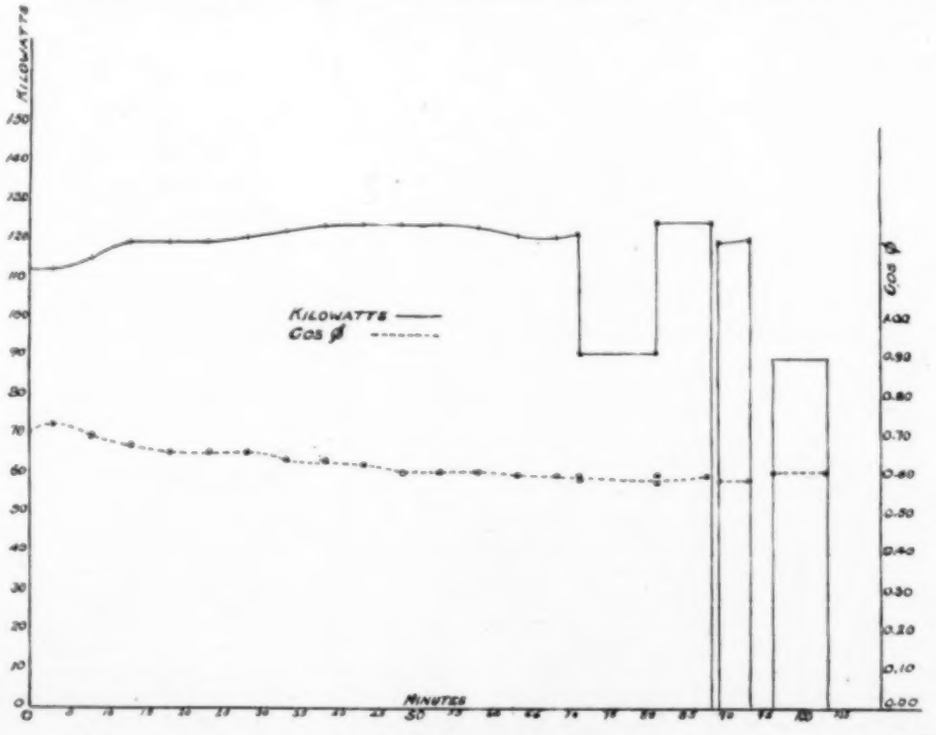
Finally, when heat is generated in the metal by passing a current through it, the rate of generation is simply equivalent to the wattage of the current. Once a molten bath of metal is obtained the temperature may be held constant by feeding in cold metal, which will take up the heat given by the current as fast as it is generated. In this case the limit is fixed by the "pinch" effect.

Now, in any electric furnace used for melting, of the total energy generated a part is used in fusing the metal and raising it to a certain definite temperature, and a part is radiated into space. All other conditions being the same the heat radiated into space while melting a ton of metal will be directly proportional to the time of melting, therefore the more rapidly the heat is supplied to the metal the less will be the heat loss by radiation and the higher will be the thermal efficiency of the furnace.

While a good deal of information can be found in reference to the induction furnace, which is a good example of heating metal by the passage of a current through it, there does not appear to be any published account of an experiment made with the object of forming some notion of its efficiency as a melting apparatus.

At the demonstration plant of the American Electric Furnace Company there are facilities for making such an experiment, and with the co-operation of Mr. T. Rowlands, the works manager, an experiment was made on the melting capacity of one of the furnaces installed there.

The 125-kilowatt furnace has a holding capacity of approximately 2000 pounds of steel, and pours about 1200 pounds at a time. The normal voltage of the primary coil is 525 volts, but by means of a regulating device used in connection with the transformer this voltage may be varied between 475 and 600 volts. There being some uncertainty as to the accuracy of the switchboard instruments it was considered desirable to calibrate these immediately after the experiment, and this was accordingly done by the courtesy of the Canadian Niagara Power Co., who used their standard instruments for the purpose.



INDUCTION FURNACE EXPERIMENTS.

Before the test run the furnace had been standing with a molten steel bath of about 850 pounds. As soon as the test commenced the pressure on the primary was raised to 580 volts.

Three minutes later charging was begun, the material of the charge consisting of 450 pounds of washed metal and 450 pounds of muck bars, or 900 pounds in all. The charge was completely melted in 68 minutes. The primary pressure was then cut down to 475 volts and the small amount of slag on the surface of the bath removed. The removal of the slag occupied about 10 minutes. The voltage was then raised and ferrosilicon and ferromanganese put in the bath. From the time of starting to add the alloys until casting was 12 minutes, but for 1 minute of this time the current was cut off to permit of making some adjustments of the electrical apparatus. The current was off for 3 minutes while making the first cast of 450 pounds and was then thrown on again for 7 minutes while preparing the ladle for the second cast of 450 pounds. There was no reason why the second cast should not have been made immediately after the first without putting on the current again if the ladle had been ready.

In the following table is given an analysis of the time and energy consumption during the heat:

	Running Time in Minutes	Kw.-Hours.
Preliminary heating	3	5.6
Melting	68	137.1
Removing slag	10	15.3
Melting finishing alloys	11	22.7
Heating before second cast	7	10.7
Total	99	191.4

Total charge.....900 pounds.
Total time.....1.72 hours.
Mean kilowatts while running.....116 kilowatts.
Maximum kilowatts.....125 kilowatts.
Energy consumption per ton (2240 lbs.).....476 kw-hours.
Energy consumption per ton (2240 lbs).....638 hp-hours.

The curves show the kilowatts and the power factor throughout the run.

During the experiment the highest attainable voltage was used, yet the "pinch" effect was not obtained, so that this experiment unfortunately has not shown just where the limit lies. However, the results seem to be of sufficient interest to be worthy of publication and to show why the induction principle is one worthy of consideration in heating materials electrically.

FITZGERALD AND BENNIE LABORATORIES,
NIAGARA FALLS, N. Y.

Heat Conductance and Resistance of Composite Bodies.

BY CARL HERING.

The object of the present article is to reduce to their simplest forms the various formulas for calculating the heat conducted through composite bodies, that is, through those consisting of layers of different materials having different conductivities, dimensions or temperature ranges, therefore involving complications in the calculation of the heat which will be conducted through them.

The walls of a furnace, when made of layers of different materials, is an illustration of such a case. In well-constructed furnaces, particularly the electrical, in which the economy of heat is of more importance, it is customary and very good practice to use for the inside layer of the walls a material which is chosen for its refractory quality, and for the outer layer one chosen for its heat insulating property. Sometimes it may even be well to use a layer of a third material between them. Firebrick is a good refractory material, but only a fairly good insulator, while infusorial earth is a very good insulator, but loses that property at high temperatures.

The usual simple formula for calculating the heat losses through walls, or their heat conductance, is not well suited for cases in which the heat travels transversely through two or more different materials in series, because it involves taking the reciprocal of the sum of a number of reciprocals, as the temperatures at their junctions are not known; it, therefore, is a tedious calculation and the formula looks so formidable (it looks worse than it is, if the arithmetical calculations are made in their proper order) that it often encourages the alternative process of guessing, sometimes disguised under the term "estimating."

The usual and well known formula for calculating the heat conducted by a body is as follows:

$$H = \frac{skt}{l} \qquad (1)$$

in which s is the cross-section of the body in square centimeters, l its length in centimeters, t the difference of temperature in Centigrade degrees between the inside and outside surfaces of the conductor, and k the heat conductivity stated in absolute units (gram calories, cubic centimeter and Centigrade degree), then H is in gram calories per second. Or if l is in inches, s in square inches, t in Fahrenheit degrees and k in thermal unit, cubic inch, Fahrenheit units, then H is in thermal units per second.

In this formula the conductivity k is assumed to be constant throughout the whole conductor; this is not always the case, particularly at great ranges of temperatures, hence either the larger value or a fair mean for the average temperature must be used. The formula also assumes that there is no loss of heat from the other sides of the body, or, in other words, that all the heat which enters on one side, leaves on the opposite side only; this is the case with all walls which surround furnaces, but not with rods whose sides are exposed to the air, when heated at one end and cooled at the other. The formula also assumes that the temperatures are those of the two surfaces of the walls, which temperatures are usually given or assumed; when the inside contains a liquid and the outside is water-jacketed, there will probably be no material error in assuming the temperatures of the wall surfaces to be those of the respective liquids, but when the heating and cooling bodies are gases there may be important differences of temperatures between them and the walls; the present article deals only with the conduction of the walls themselves, and not with this contact resistance.

In the above formula the quantity sk/l is the part called the conductance, which may be represented by C. Just as in accordance with Ohm's law, the electrical conductance multiplied by the difference of potential in volts gives the current, so this heat conductance C multiplied by the difference of temperature t gives the flow of heat per second, H. This conductance C must, therefore, be clearly distinguished from the flow of heat H. C is a constant in any particular case, depending on the size, shape and quality of the material; H, the flow, is a variable depending on the temperature. When C is known, H is readily calculated from it.

Whenever a conductor consists of different materials separated by surfaces parallel to the direction of flow of the heat, as, for instance, when a graphite rod, Fig. 1, is surrounded by a thick iron cylinder, or by a tube of firebrick, that is, when the heat flows through the different parts in parallel, this quantity, conductance, is the most convenient one to use in calculations. In this case the length l is the same for all of the parts, hence if s, s', s'', etc., are the cross-sections of the different materials, and k, k', k'', etc., are their respective conductivities, the formula for the conductance of the whole composite body becomes:

$$C = \frac{sk + s'k' + s''k''}{l} \qquad (2)$$

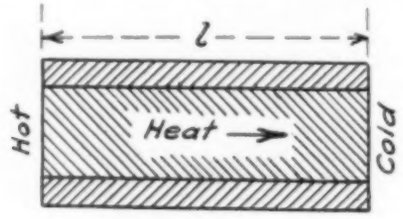
or merely the sum of the various parts,

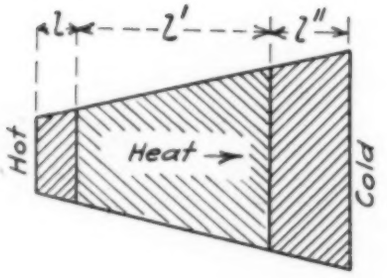
$$C = \frac{sk}{l} + \frac{s'k'}{l} + \frac{s''k''}{l} \qquad (3)$$

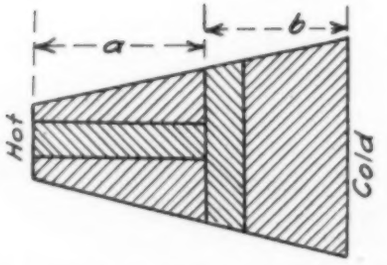
Or if the lengths of the parts are also different the formula becomes

$$C = \frac{sk}{l} + \frac{s'k'}{l'} + \frac{s''k''}{l''} \qquad (4)$$

If, however, as is far more usual in furnace walls, the different materials are in layers perpendicular to the path of the heat, as in Fig. 2, that is, when the heat flows transversely through them in series, the formula for the conductance be-







FIGS. 1, 2 AND 3.—COMPOSITE FURNACE WALLS.

comes awkward. In such cases, a formula analogous to that used for electricity is the more convenient. In the latter the reciprocal of the conductance is used and is called resistance, while the reciprocal of the conductivity or specific conductance is called the resistivity or specific resistance. Such quantities are not common in heat calculations, and, unfortunately, have no names, and no units; but there is no reason why analogous reciprocals should not be used, and many reasons why they should. It is perfectly correct to use them. They are very useful; they often simplify the calculations and they afford a simple means for calculating the temperatures at the junctions of such layers.

While this analogy between thermal anl electrical conductance and resistance is very useful, it may lead to grave errors if carried too far; it must be remembered that it is not an identity and that there are important differences. Ohm's law gives the amount of *current*, but not of power, which will flow through a resistance at a given voltage, while the analogous heat law gives the *power* in the form of calories per second, which will flow through a heat-resisting body at a given difference of temperature. When reduced to the same quantities, the temperature factor in the one corresponds to the square of the voltage in the other, hence the analogy is not complete.

In this analogy between Ohm's law and the heat law, it must be understood that the factor called the heat conductance in the above formula (1) is only the part sk/l and that the heat conductivity is the factor k. It will then be correct to consider the reciprocal of the former, namely, l/sk, which may be represented by R, to be the thermal resistance; and the reciprocal of the conductivity, namely, $1/k$, represented by r, to be the thermal resistivity. It will then be correct to express the analogue to Ohm's law in the form

$$H = \frac{t}{R} \qquad (5)$$

More usually this is stated in the other form

$$H = Ct \qquad (6)$$

in which C is the thermal conductance, for which there is unfortunately no named unit.

Like with electricity, the following formulas apply:

$$R = \frac{1}{C} \qquad (7)$$

$$r = \frac{1}{k} \qquad (8)$$

$$C = \frac{sk}{l} \qquad (9)$$

$$R = \frac{lr}{s} \quad \text{or} \quad \frac{l}{sk} \qquad (10)$$

In this connection it may not be out of place to call attention to the distinctive electrical terms used, and to urge that the same be used in thermal nomenclature also. It has reference to the terminations *-ance* and *-ivity*. Resistance and conductance, which are the reciprocals of each other, refer to a particular piece of material of given dimensions and substance; they are analogous to the weight of a given body; thus, the electrical resistance of a particular rod is so-and-so many ohms, or the thermal resistance is so-and-so many thermal resistance units, which, unfortunately, have no name. Resistivity and conductivity, which are also reciprocals of each other, refer to a property of a material, regardless of its size or shape; they are analogous to the density of materials; they are physical constants for specified material and as such are given in tables of constants. Thus the resistivity of copper is a certain constant, differing from that of iron. They were formerly called specific resistance and specific conductance. It is, therefore, incorrect and tautological to speak of the specific conductivity or specific resistivity.

Referring to Fig. 2, which represents the case in which the resistance formulas are the more convenient, namely, when the heat passes successively through transverse layers of different materials, let s, s', s'', etc., represent the cross-sections in square centimeters, of the successive parts, perpendicular to the path of the heat; l, l', l'', etc., their respective lengths in centimeters in the direction of the flow of heat; r, r', r'', etc., the respective thermal resistivities of the different materials, and equal, respectively, to the reciprocals of the conductivities k, k', k'', etc.; then, like in electrical calculations, the formula for the total thermal resistance from one end to the other, is simply the sum of the individual resistances, namely,

$$R = \frac{lr}{s} + \frac{l'r'}{s'} + \frac{l''r''}{s''} \qquad (11)$$

The loss of heat through this resistance is then determined from formula (5).

As the tables of physical constants usually give the conductivities instead of the resistivities, this formula (11) is more convenient in the following form:

$$R = \frac{l}{sk} + \frac{l'}{s'k'} + \frac{l''}{s''k''} \qquad (12)$$

If the cross-sections are the same for all, as, for instance, for a thin slab, formula (11) becomes

$$R = (lr + l'r' + l''r'') \div s \qquad (13)$$

and (12) becomes

$$R = \left(\frac{l}{k} + \frac{l'}{k'} + \frac{l''}{k''}\right) \div s \qquad (14)$$

Such thermal resistances can, of course, be compared with each other, reduced to percentages of each other, etc., just like any other physical quantities, and it is generally not necessary to reduce them to the heat loss in calories per second, until this particular quantity is desired. If for a certain furnace and certain differences of temperature, a specified heat loss is allowed, then it is best to calculate once for all from formula (5) what the corresponding thermal resistance will be; all the sometimes very numerous trial calculations, for different materials, shapes and thicknesses, can then be made in terms of the resistances by means of the above simple formulas, just as is done in electrical calculations, instead of reducing each one of these calculations to heat losses.

Another case in which the use of thermal resistances instead of conductances simplifies calculations is the case shown in Fig. 3, in which there is a combination of layers, some of which are parallel to the path and others perpendicular to it. In such a case the calculation of the part *a* is first made in terms of the joint conductance of its parts, by means of formulas (2), (3) or (4). This total conductance is then reduced to resistance by taking its reciprocal (7) and the part *a* as a whole may then be considered as another transverse layer like those in the part *b;* its resistance thus obtained must then be added to the resistances of the parts *b* by means of formulas (11), (12), (13) or (14). In this it is, of course, assumed that the temperature is uniform all over the junction of the parts *a* and *b*.

The formulas in terms of resistances also enable one to determine the temperature at the junction of any two layers of Fig. 2. This may at times be important and give unexpected results. For instance, if the inside layer of a high-temperature furnace is firebrick, which does not insulate well at high temperatures, and the outside is infusorial earth, which loses its good insulating quality when highly heated, it may be important to determine the actual temperature at their junction, in order to find out whether the actual ranges of temperatures between the junction and the two end surfaces correspond with those assumed in selecting the proper conductivity from the tables. Also to see whether the temperatures of the cooler layers exceed the limit which they can stand, as, for instance, with felt or glass-wool. The temperature of the junction will probably be found to be higher than was expected.

Just as the voltage in an electrical circuit falls in proportion to the electrical resistance, so the temperature at the junctions of the transverse layers in Fig. 2 will fall proportionately to the thermal resistances. For instance, let T, T', T'' be the falls of temperature in the three successive layers in Fig. 2, and $T+T'+T''=t$, then the fall through the first layer will be, from formula (12),

$$\frac{T}{t}=\frac{l/sk}{R},$$

or

$$T=\frac{tl}{Rsk} \qquad (15)$$

or from (5) and (10)

$$T=HR_1 \qquad (16)$$

in which R_1 is the resistance of the layer.

Through the second layer the temperature drop will be

$$T'=\frac{tl'}{Rs'k'} \text{ or } HR_2$$

and so on.

The above formulas are all numerically correct if the quantities are in terms of the units stated above, namely, the Centigrade, the centimeter, gram calorie and Centigrade degree. If, however, the units are the inch, square inch, thermal unit, (pound Fahrenheit unit), Fahrenheit degree, and the conductivity or resistivity is in the thermal unit, cubic inch unit, then these formulas will also be numerically correct and the loss of heat will be in thermal units per second. Any other combination of units may be used, provided it is done consistently throughout, special care being taken with the values of k and r (see below). In this country it may often be most convenient to use the inch and the calorie, and, therefore, the Centigrade degree, while the conductivity k most generally found in the best tables is in the calorie, cubic centimeter unit, also called absolute or c.g.s. units. With this mixed or hybrid system of units formulas (1) to (6) and (9) will be correct if the right-hand side be multiplied by 2.54, and (10) to (16) if multiplied by 0.3937 (approximately 0.4). Formulas (7) and (8) are, of course, the same in any system of units.

The conductivities or specific conductances k as found in the best tables are usually stated in terms of the gram calories per second, the cubic centimeter and the Centigrade degree; they are then said to be given in absolute or c.g.s. units. To reduce these constants to cubic inch units, but still retaining the gram calorie and the Centigrade degree, multiply this conductivity k by 2.540 (or approximately by 10/4). Thus for firebrick this constant is given in tables as 0.0014, meaning that so many gram calories will flow per second between the two sides of a centimeter cube, for 1° C. difference of temperature. When this is multiplied by 2.540, giving 0.00356, it is in cubic-inch units, gram calories per second and Centigrade degrees. To reduce the original constant 0.0014 to thermal units, inches and Fahrenheit degrees, multiply it by 0.00560, thus giving 0.000,007,83 for firebrick.

To reduce gram calories per second to watts, multiply by 4.186; to reduce them to thermal units multiply by 0.003,968. To reduce thermal units per second to watts multiply by 1054.9.[1]

The following numerical examples will illustrate the use of the formulas:

An electrode of soft steel, 4 in. square (cross-section, 16 sq. in.), passes through the wall of a furnace 12 in. thick and is surrounded on all sides (but not on the ends) with 4.5 in. of firebrick (cross-section $(4.5+4.+4.5)^2-16=153$ sq. in.). The temperature of the hot end is 500° C. and of the cold end 20° C. How much heat will flow through both together? This case is illustrated in Fig. 1; both conduct in parallel. According to Richards[2] the heat conductivity of such iron is 0.11 and of firebrick 0.0014 in gram calories, centimeter and Centigrade units. Formula (2) is the one to use, as this is a case of two conductances in parallel. But the conductivities are stated in cubic centimeter units, hence they must both first be multiplied by 2.54, or better, the whole right-hand side must be multiplied by that factor. Hence the joint conductance is

$$C=\frac{(16\times 0.11)+(153\times 0.0014)}{12}\times 2.54=0.403 \text{ conductance units,}$$

hence, according to formula (6), the heat loss is

$$H=0.403\times 480=193. \text{ gram calories per second.}$$

The two quantities in the numerator of the former, namely, 1.76 and 0.214, also show the relative losses of heat through the two parts, as they will be in proportion to the conductances; hence about eight times as much goes through the steel as through the firebrick.

Referring to Fig. 2, let the linings of a furnace consist of a 4-in. layer of firebrick on the inside, then a 5-in. layer of infusorial earth, covered with 3 in. of felt on the outside. The temperature of the inside surface is 1300° C. and of the outside surface 50° C. The inside dimensions are 12 in. cube. What is the total heat loss, and what will be the maximum temperature of the infusorial earth and of the felt? This is a case of conducting layers in series, hence the resistance formulas are the simpler to use. As the lengths, cross-sections and conductivities are all different, formula (12) is the best one to use when the constants taken from the tables are conductivities or (11) if they are resistivities. The conductivities taken from Richards cited above, are for firebrick from 0-1300°, 0.0031; for infu-

[1] For other reduction factors see "Conversion Tables," Hering.
[2] This journal, March, 1906, pp. 100 and 103.

sorial earth from 0-650°, 0.00038, and for felt, 0.000087. The firebrick, however, will evidently all be at a high temperature, and as the conductivity increases rapidly with the temperature, the above value will be too low. By a calculation which cannot be explained here, it is found to be 0.0042 for 500° to 1300°. As all of these are in c.g.s. units, while the dimensions are in inches, the total resistance must be multiplied by 0.4 as described above.

The average cross-section of such walls, which enlarge greatly toward the outside, is usually taken as the arithmetic mean between the two extremes.[2] The mean cross-section of the firebrick will, therefore be $(144+400)\times 6\div 2=1632$ sq. in.; of the infusorial earth $(400+900)\times 6\div 2=3900$; and of felt $(900+1296)\times 6\div 2=6588$.

Hence, the total resistance according to formula (12) is found to be.

$$R=\left(\frac{4}{1632\times 0.0042}+\frac{5}{3900\times 0.00038}+\frac{3}{6588\times 0.000087}\right)\times 0.4$$

$R=(0.583+3.38+5.23=)\ 9.19\times 0.4=3.68$ in resistance units, hence from (5) the heat loss is

$$H=\frac{1250}{3.68}=340.\ \text{calories per second.}$$

The relations of the three parts in the equation above, which added together make the total R, show how small a heat insulating effect the firebrick has, only about one-sixth that of the infusorial earth and one-ninth that of the felt; by far the larger part of the insulation is that of the felt.

To find the temperature of the hot side of the infusorial earth, calculate from formula (16) the drop of temperature through the firebrick.

In this formula R_1 is the resistance $0.583\times 0.4=0.233$ found above for that firebrick, hence

$$T=340.\times 0.233=79^\circ\ \text{C.}$$

hence the hot temperature will be $1250-79=1171°$. Similarly, the fall of temperature through the felt will be

$$T=340.\times 5.23\times 0.4=711^\circ.$$

Hence, the temperature of the hot side of the felt will be $711+50=761°$ This, of course, is far higher than felt will stand; the range of temperature for the infusorial earth will, furthermore, be from 761° C. to 1171° C., which is a much higher range than that assumed in selecting the constant for the conductivity from the tables. Both of these show that the proposed proportions, or the whole design, must be changed, and this first trial calculation shows the directions in which these changes must be made. The data for this problem were selected for the purpose of showing the advantages of calculating the intermediate temperatures, in checking the correctness of designs and proportions.

Suppose in an electrical furnace of 500 kw, with an inside temperature of 1500° C., and outside 100° C., it is desired that the heat loss through the walls of the furnace does not exceed 25 per cent.

This loss will, therefore, be 125,000 watts $\times$ 4.186 = 30,000 gram calories per second.

From formula (5)

$$R=\frac{t}{H}=\frac{1400}{30{,}000}=0.0467\ \text{heat resistance units.}$$

Hence, to limit the loss to the desired amount the combined heat resistance of all the walls must not be less than 0.0467 units. Trial calculations are then made with formula (12) for different materials and different proportions of lengths and cross-sections until some combination is found which will give at least this insulation resistance.

[2] This is only approximately correct. See a paper by the writer, read before the Amer. Electrochem. Soc., October, 1908, abstracted in the December, 1908, issue of this journal.

Some Fundamental Considerations on Coal.

By W. Jones,
Chemist for the Metropolitan Street Railway System, of New York.

While it is surprising, it is none the less true, that of all supplies purchased by a manufacturing concern the one that receives the least attention, and in the majority of cases is wasted, more than all others, is coal.

It is so very easy to make a fire and obtain heat that people seem to think that if they only get the heat they want that is all that is necessary. They do not for a moment stop to think of the cost of the heat, nor do they consider what amount of heat is utilized, and what amount is wasted. To be sure, large steam plants are beginning to take up this matter, but in most cases it is only in a half-hearted way.

In using coal we find many points to be considered, not only the proper combustion of the coal, but what is just as important, the use of the coal that is best suited to the work to be performed.

This naturally brings us to the purchase of the coal to start with. It is of no use to say that a certain grade of coal is the best for a certain purpose, or that a coal having 15,000 B.t.u. is better for us to use than one having only 14,000 B.t.u. Of course, we all understand that the more heat in a coal, the better in general, other things being equal, but when we take into consideration the use it is to be put to and the kind of furnace we are to use, this is not necessarily the case and the lower grade may be the better for our purpose.

Again, we cannot all have the highest grade of coal, and it is necessary that we use the coal that the market affords, or that which is produced in that part of the country where we wish to use it, so that in many cases it is not optional with us what coal we shall use, but rather how to make the best use of what we can get.

The manager of a plant generally gets what he considers the cheapest coal he can buy. By this I do not mean the poorest coal, but what he considers the best for the price. He usually does not give the slightest attention to the composition of the coal or its heating value, and if there is no choice of coal, he still less thinks about building his furnaces so as to get the best results from what coal he can get.

We will consider, for instance, the use of coal for raising steam. Let us suppose a furnace of such dimensions as to burn with good results a coal having 6 per cent ash, 16 per cent volatile matter, and 78 per cent fixed carbon. This is what would be considered a first-class steam coal, and in the furnace used, it gives fine results.

Now let us go to the West where such a coal cannot be had, but in its place we get coal of the following analysis: ash, 15 per cent; volatile matter, 30 per cent; fixed carbon, 55 per cent. It stands to reason that such a coal would not give us the same results in proportion to its contained heat, if we burn it in the same furnace.

We would be likely to produce too much smoke, and the combustion would not be perfect; or, if it was, the zone of combustion, where the heat is most intense, would be so far removed from where we want it that the heat would be largely lost in the flue. But with a knowledge of the composition of the coal, a furnace could be constructed that would give us results equal to the other.

Again, when we come to metallurgical work in a reverberatory furnace, we need a coal that will give a more or less long flame. This means a certain amount of volatile matter, and the amount of volatile matter in the coal would determine the best shape and construction of the furnaces. I have known cases where a coal which gave the best of results in a large reverberatory, was used to raise steam, with the result that steam could not be kept up; but when a coal of a much lower grade, which could be had for about one-half the cost, and which did not contain so much volatile matter, was used, there was no

trouble. Simply, on account of its construction, the furnace was not fit for the combustion of the higher grade coal, or, if the furnace had to be used, as it stood, a lower grade of coal had to be used.

In determining then what coal to buy or how to build the furnace to suit the coal to be had, it is necessary to have the proximate analysis of the coal.

On the other hand, to determine what efficiency we are getting, it is necessary to have the B.T.U. or heating value of the coal.

These analyses should be made on all coal as received, so that we may know that we are getting the coal and heat we are paying for.

For determining the heating value of coal, we find many forms of calorimeters on the market, but unfortunately the cheaper ones, which are largely used, are of little value, as the results they give are not only not constant, but are generally much too low. The same coal in such an instrument will vary as much as 5 per cent. The correct determination of the heating value of a coal can best be made in the bomb calorimeter, such as Mahler's or some modification of it, in the hands of a careful man. Tests of this kind require, of course, experience and carefulness.

It would, therefore, seem to be wisdom on the part of any manager to buy his coal on analysis and heating value, and then to use it in such a way as to get the best results from it; that is, to see that his heat goes to making steam and not passing into the flue.

This, then, brings us to the combustion of the coal, so as to get the desired results. To get these, it is not only necessary to build the furnace to suit the coal, but we also have to regulate the thickness of the fire bed and the amount of air, so that the proper combustion takes place and the heat is produced where we want it, without using an excess of air, which, of course, only cools the fire.

After we have got our furnace built and running, we should watch the flue, as all heat entering there, of course, does not make steam, but is lost.

We should make frequent analyses of the gases entering the flue, and in the case of soft coal we should get about 14 to 15 per cent CO_2.

The percentage of the carbon dioxide gas is a very good guide as to the amount of excess of air that is being used in proportion to the coal burned. It is, however, not only necessary to have a high percentage of CO_2, but it is also necessary to maintain a low temperature in the flue, as any fireman can get a high-percentage gas, with a high flue temperature, and at the same time have a large loss of heat in his flue. Hence, when determining the amount of heat lost in the flue, the temperature in the flue should be determined by means of a thermometer when taking the gas sample. Then by using the following formula we can find approximately the loss of heat. The heat loss in per cents $= \frac{T-t}{C} \times 0.36$. Here T is the temperature of the flue in degrees Fahrenheit and t the temperature of the air entering the grates. C is the percentage of CO_2 in the gas.

This loss should not be over 17 per cent, and when economizers are used, should be still less.

By testing the gas at the intake of the economizer and again at the outlet, we get very closely the saving of heat in the economizer.

It is frequently the case that where economizers are used a much larger amount of heat is allowed to enter the flue and go to the economizer to be absorbed there and so saved. I know of cases where gases entering the economizer showed a loss of heat of 30.3 per cent and 32.2 per cent, and after passing the economizer they showed only 14.9 per cent and 16.6 per cent, so that the economizer produced a saving of 15.4 and 15.6 per cent, respectively.

A New Polishing Machine for Metallographic Work.

By James Aston.

In metallography, the proper polishing of the specimens for microscopic examination is a most important detail. One of the very best methods is hand rubbing upon polishing mediums of varying degrees of fineness, mounted upon wooden blocks. While this method has the advantages of simplicity and flexibility, it has the great disadvantage of being very laborious, and has consequently been almost superseded by mechanically driven polishing machines.

With these machines the time factor has been placed upon a satisfactory basis, but there is still plenty of room for improvement in other details. For example, there is a lack of flexibility. One is limited to, say, four different surfaces for polishing, which is only sufficient for material of one character, and does not give the necessary range where the specimens may vary in nature from the softest brass to the hardest steel, since polishing powders suited to one material are not satisfactory for another. Where the disks are changed, it is usually done only with considerable trouble. Another most serious objection is that where one machine is used by a number of persons, as in a students' laboratory, there will always be the condition of the careful worker being compelled to rectify, or to suffer from, the results of another's carelessness in getting rough powders on fine disks, or tearing polishing cloths, etc.

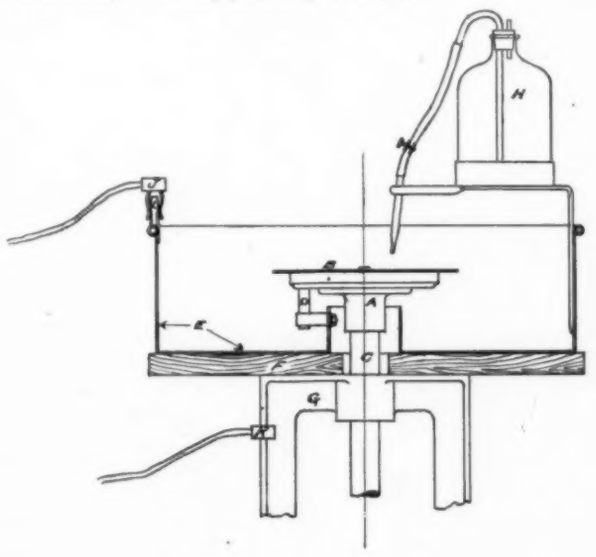


FIG. 1

VERTICAL SECTION OF APPARATUS.

To eliminate some of these undesirable features of polishing apparatus, there has been devised at the metallographic laboratory in the Chemical Engineering Department of the University of Wisconsin, a machine which has proven so superior to the common type, that it has been thought advisable to present a description of it as being perhaps a matter of interest to others engaged in metallographic work.

Fig. 1 shows a vertical section of the apparatus. As will be seen, it is of the vertical spindle type, with rotation of the polishing surface in a horizontal plane, which is conducive to better results than where the disks are vertical. The distinguishing feature is the magnetic clutch A, which holds down the polishing disk B, and which is illustrated in detail in Fig. 2. The clutch, which is 6⅛ in. extreme diameter, consists of two cast-iron parts, T and S, electrically insulated from each other by hard rubber, as shown. W is the magnetizing winding, one terminal being connected to S at Y, the other to T at Z. X is a plate of non-magnetic material, such as aluminium or brass. Thus, when current is sent through the magnetizing coil, the

magnetic circuit is completed through the sheet-iron polishing disk *R*, and it is held tightly to the clutch surface.

Referring again to Fig. 1, the part *S* of the clutch, and consequently one terminal of the magnetizing coil, is in electrical connection with one terminal of a storage battery through the spindle *C*, frame *G*, and connecting cable and clip *K*. Part *T* of the clutch, with the other terminal of the magnetizing coil, connects with the other pole of the battery through the contact brush *D*, the galvanized iron drip pan *E*, and the cable and

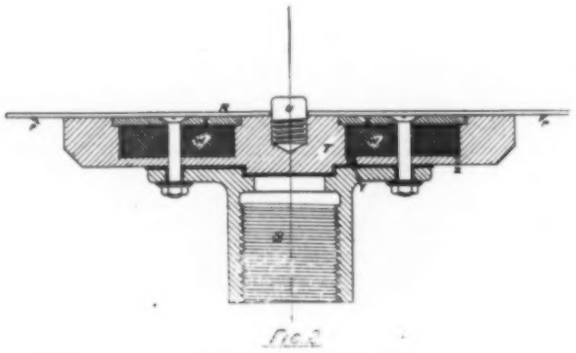


FIG. 2

MAGNETIC CLUTCH.

clip *J*; *J* and *L* being at the same time used as a switch to make and break the magnetizing circuit. The wood base *F* insulates the pan *E* from the frame *G*.

The polishing disks are of sheet iron, about No. 18 gage, and 8 in. in diameter. At twelve points near the circumference, V-shaped cuts are made, and the points bent down and sharpened (as shown at *P*, Figs. 2 and 3), thus forming fasteners upon which to hook the polishing cloth.

In the operation of polishing, the spindle is set in rotation and the desired disk slipped over the centering pin *U* (Fig. 2)

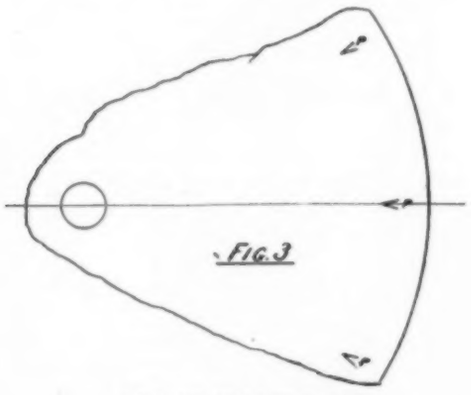


FIG. 3

PART OF POLISHING DISK.

and gripped by closing the circuit at *J* — *L*. Water for wet polishing is obtained from the bottle *H* (Fig. 1) and the flow regulated by a pinch cock. In changing disks, it is only necessary to open the circuit at *J* — *L*, remove the disk *B*, and substitute a new one without stopping the machine. The energy for magnetizing is very little, a current of 1.3 amperes from a 6-volt storage battery being sufficient.

In conclusion, the advantages of this apparatus may be summarized as follows:

1. The rotation in a horizontal plane (although the principle could be applied to vertical rotation as well).

2. The ease of manipulation in changing polishing mediums.

3. The flexibility, since an endless variety of surfaces, such as linen, broadcloth, felt, chamois, leather, parchment, etc., can be easily prepared, and treated with any desired polishing powder. Or the surface of the disk could be lead plated, or otherwise treated, for special purposes.

4. Worn out cloths can be easily changed, since no complicated fastenings are required.

5. Each operator can have his own set of disks, since they are very easily and cheaply made. In the case of students, this fixes the responsibility for the quality of each man's work.

6. Because of the little space occupied, disks can be set vertically in small portable racks, so that while in use they can be at the hand of the operator, and when not in use they can be put away in dust-proof cupboards.

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Smelting of Iron Ore in the Electric Furnace, in Comparison with Blast Furnace Practice.

By Joh. Härdén.

The problem of electric smelting of iron ore without the use of a blast furnace has been so often alluded to of late that a critical discussion of the subject, and comparison with blast-furnace practice, seems justified.

The matter has been the subject of a number of articles in various technical papers. References will be found at the end of this article.

It may be advisable to first consider the expenditure of coal for heat and reduction in the blast furnace, so as to obtain figures for comparison. The theoretical figures are partly taken from H. Jüptner's "Siderologie," Part III (which may be regarded as a reliable authority), and are partly obtained by direct calculation.

The practical figures are obtained from blast furnace plants in practical operation, and from a production extending over several years. The furnace in question is operated with charcoal, but the thermal effect does not differ much from that of a coke furnace.

As regards the electric furnace, the figures for these are obtained from the report of the Canadian commission (E. Haanel), from A. Stansfield's and W. A. Borcher's books on electric furnaces, as well as from the author's own observations.

Reduction of Iron Ore in the Blast Furnace.

For the reduction of 1000 kg (1 metric ton) of pig iron (not including the necessary heating) we require:

From	Fe O (Protoxide)	214.3 kg	carbon.
	Fe_3O_4 (Magnetite)	285.7 "	"
	Fe_2O_3 (Hematite)	321.4 "	"

Assuming all carbon oxidized to CO only.

These reactions, however, also require an elevated temperature, and the necessary heat has to be derived from coal or from electric energy.

Now it is true that the reaction is practically not heat-consuming if the carbon is supplied in the form of CO instead of as free carbon (coal, coke or charcoal). But, as is well known, it is necessary, for practical reasons, to supply the carbon in the free state and try to arrange the operation so that as much as possible of the iron is reduced by means of the CO developed. It will be seen that this is of special importance in the case of electric smelting. How far this result is obtained in blast-furnace practically will also be shown.

The energy required for the *reduction* of the iron ore only, per metric ton of pig iron, is from:

Fe O	832,000 kg calories.	
Fe_3O_4	943,000 " "	
Fe_2O_3	1,058,000 " "	forming CO from C.

For the present it will be quite sufficient to confine ourselves to the smelting of Fe_2O_3 (hematite), as this class of ore has proved most suitable for treatment in the electric furnace, being easily obtained in the form of briquettes. As the theoretical figures for the other classes of ore are given above, they may be easily applied to the calculations for electric smelting.

We may assume that the fuel in question (wood charcoal, for

reasons given below) has a calorific effect of 7500 and contains 80 per cent carbon, which is a fair average.

Owing to the reverse oxidizing action of CO_2 on iron, in actual practice only, at most, one-third of the carbon can be converted to dioxide. On this assumption, the carbon necessary for the chemical reaction of reducing 1 ton of iron from hematite is 241.1 kg of carbon, or 301.0 kg of 80 per cent charcoal.[1]

On the same assumption, the energy required is:

For the reaction.....	732,000	Calories.
For the melting of the iron.....	310,000	"
For the melting of slag.....	72,000	"
Total.....	1,114,000	Calories.

Now, again, on the same assumption, the calorific effect of the fuel when burnt to $CO_2 \times 2\,CO$ is about $3250 = (\frac{2}{3} \times 0.3 + \frac{1}{3} \times 0.7)$, but each kg of charcoal burnt for this purpose (again on the same assumption) requires $\frac{64}{36} \times \frac{100}{23} \times$ kg of air, and this is heated to about 800° C. by a portion of the waste gases. There are thus reintroduced into the furnace with the blast $\frac{64}{36} \times \frac{100}{23} \times 800 \times 0.24$ calories $= 1486$ calories per kg of fuel burnt, which raises the *effective* calorific power of the fuel to $3250 + 1486 = 4696$ calories. Therefore, the amount of fuel required for heating purposes will be

$$\frac{1114000}{4696} = 237 \text{ kg.}$$

We have already stated that the reduction only would require 321.4 kg carbon; assuming that the charcoal contains 80 per cent free carbon, we would have to spend $321.4 \times \frac{100}{80} = 404$ kg charcoal, for reduction, and 237 kg for heating, but, for the reasons given above, we are able, by properly regulating the operation, to reduce the total expenditure to 538 kg of charcoal for each ton of pig iron produced.

If we compare this figure with those actually obtained we find:

At the Herrang Works, in Sweden, where chiefly hematite briquettes are smelted by means of charcoal, the average consumption taken over a period of three years was 570 kg per ton of pig iron produced.

This may be considered as a very favorable figure; as the blast furnace is by no means giving 94 per cent efficiency, we must assume that the operation was so regulated that an even larger quantity of iron was reduced by means of the CO formed than assumed above.

The average price paid at these works for charcoal delivered from a kiln was $12 per ton. Thus, the cost of fuel per ton of pig iron would be $6.84, of which $4.84 is paid for the reduction and the remaining $2 for the heating.

We will now compare this with **electric smelting.**

We will assume that the ore again consists of hematite briquettes, because in this form it is more convenient to charge, and will not strain the lining as much as magnetite, besides being more readily obtainable. Should the latter be used, however, the comparison will be sufficiently accurate, for although the Fe_3O_4 will need only 285.7 kg of fuel per ton of reduced iron, the heat consumption is also less than with hematite, or 943,000 calories, against 1,058,000, so that the proportion will be nearly the same.

We need here, as for the reduction of 1 ton of pig, 404 kg coal, costing, say, $4.84.

The design of the furnace will present certain difficulties in arranging the operation so that the bulk of the iron is reduced by means of CO, owing to the difficulty of producing a shaft, as in the blast furnace, for this would interfere with the application of the source of heat, as will be shown later. Assuming, however, that it is possible to reduce, say, 50 per cent of the iron by means of CO (which is probably not an underestimate), we need for the reduction only 529,000 calories. Furthermore, we need for the heating of the iron and the slag another 382,000 calories, as before, or altogether 911,000 calories. If we assume that the thermal effect of the electric furnace is 60 per cent (which has really been obtained in practice), we find that we have to spend 1,518,300 calories. As one kw-hour is equal to 860 calories, we will thus have to spend 1768 kw-hours.

This corresponds well with the results reported by the Canadian commission (page 108 of their report) from Livet, where an average of 0.3 hp-year per ton was consumed. This will give in round figures 2000 kw-hours per ton. It also corresponds with the results obtained in a Héroult furnace, and reported by Dr. Neumann (Elektrometallurgie des Eisens, page 169), where it is stated that the reduction of 1 ton of pig iron from hematite requires 1705 kw-hours (1732 to 1989 for magnetite).

If we assume that the cost of power is $20 per kw-year (which is a fair average) or 0.226 cent per kw-hour, we find that the energy per ton of pig will cost $3.90.

In the case of electrode furnaces we have also to add the cost of the carbon electrodes, the consumption of which is rather high when smelting from ore. Dr. Neumann states (Elektromet. d. Eisens, page 170) that the consumption was 8.1 kg per ton of pig. The author's observations give a consumption of 15 kg for *steel smelting*, and it is certainly not less for ore smelting; if we assume 20 kg we will probably be closer to the mark, remembering that a large portion of the electrode has to be removed and repressed (nearly 40 per cent). If we take the price of electrodes to be, say, $0.05 per kg, we have an additional cost of $1 per ton of produced pig iron, or the sum of $4.90 for energy and electrodes alone.

We are now able to compare the two methods: viz., **blast-furnace versus electric smelting.**

Taking the conditions to be equal in both cases, as to the class of ore, amount of labor (for either a blast furnace or an electric furnace of the same yearly output, five men per shift should be required), and class of fuel available, we find on comparison that we need in either case for the reduction alone about 400 kg carbon, at a cost of, say, $4.80 per ton of iron.

In the blast furnace we have to spend another 170 kg at a cost of, say, $2.04, or a total of $6.84 per ton produced iron.

In the electric smelting furnace an expenditure of $4.80 for the reduction, $3.90 for power, and $1 for electrodes is necessary, making a total of $9.70, or *$2.86 more per ton of produced iron.*

Another important feature in blast-furnace practice is the considerable gain in the form of blast-furnace gas, which can be utilized to drive gas engines, apart from preheating the air. It is nowhere stated that such a utilization of the gas has been accomplished in the case of electric smelting, although we will not deny that it could be done.

Jüptner states (Siderologie, pages 231-240) as follows:

"One ton of charcoal, used in the blast furnace, would yield theoretically 5,290,000 calories on combustion." Others, such as Witz and Hubert,[2] state 4,320,000, and Lürmann[3] gives 4,200,000 calories. If we say that the average is 4,300,000 calories we may be nearer the mark.

Lürmann (loc. cit.) states that of this 10 per cent is lost and 31 per cent is used for heating the blast, leaving 59 per cent, while Junge[4] says that 55 per cent is available.

We may take 57 per cent as a medium figure. This gives us $0.57 \times 4{,}300{,}000 = 2{,}450{,}000$ calories in useful gas per ton of coal spent.

As before stated, for obtaining 1 ton of iron, 570 kg of coal is needed; thus, applying the above figures, we may recover 1,396,500 calories.

[1] A charcoal of 7500 calories should contain nearly 90 per cent carbon, thus giving 267 kg as necessary for the reduction.

[2] *Ann. d. Mines de Belg.*
[3] *Stahl und Eisen*, 99, 483.
[4] *Iron Trade Review.*

It is generally agreed that the most economical way of utilizing this is by means of large gas engines. Hubert states[1] that these will give an efficiency of 29 per cent, and this seems to be generally admitted. Thus, we will obtain in power recovered $1,396,500 \times 0.29 = 404,900$ calories. If we deduct from this the motive power required for the operation of the furnace, which Junge states to be about 15 per cent of the total calorific value of the gas,[2] while Lürmann's (loc. cit.) figures show that 91,000 calories are necessary; taking the mean of these figures, or 120,000 calories, we are able to recover 280,000 calories, or about 326 kw-hours per ton of iron produced.[3]

We said before that the price of electric energy was about $0.00226 per kw-hour; consequently, we recover $0.738, or the actual cost in fuel per ton of produced iron will be $6.84 — 0.738 = $6.11, against $9.70 in the electric furnace.

It is, of course, possible that the latter may be so developed that a portion of the gas may be recovered here also, especially as no heating of the blast is necessary. This, however, seems to be a matter of considerable difficulty and has not been actually claimed as far as is known to the author.

Now, a word about the furnace itself. Although there is a good deal of literature on the subject (see list at the end) no author seems to have discussed the practical side of the matter in earnest, but most have confined themselves to statements as to power consumption, character of the iron produced and, in some cases, the cost of power and labor, etc.

There are, however, practical points to be considered. It is not our intention to enter into a criticism of any furnace in particular, its advantages and disadvantages, as this is quite outside the scope of our discussion. We will only compare the various classes of furnaces proposed for the purpose with the blast furnace. Of course, the latter has been in use for ages, and has undergone a series of improvements, while the electric furnace is a child of to-day and will undoubtedly be perfected in turn.

(1) **The Electrode Furnace.**

Of this we have types in which (a) the arc is struck between carbons above the charge proper, the heat being thrown down directly and from a reflecting dome; (b) where the arc is struck between one electrode (or more in parallel) and the charge, the bottom forming the other terminal; (c) where two or more arcs play between two or more electrodes and the charge in series.

One of the great disadvantages in all electrode furnaces is that the carbons are very rapidly consumed owing to the reaction going on in the furnace, and as the electrode manufacture is both costly and difficult, this matter is of the greatest importance. In those of type (a) the consumption is somewhat less, as the arcs and the carbons are placed above the charge, hence the electrodes are also generally small in diameter, but they are easily broken off and destroyed by charging. Further, the arrangement is seemingly very ineffective, as all the heat must come from *above* the charge. We must, however, as has been shown, arrange the operation so that most of the carbon is converted into CO which passes upwards through the charge and reduces the ore, in order to decrease the cost of fuel. If the source of heat is placed above, this cannot be the case, and the efficiency is thus lowered.

This may, to a certain extent, be obviated in type (b), where the charge acts as an intermediate resistance, but here again the whole, or the largest portion of the electrode, is surrounded by the charge in the hottest zone of the furnace and is, therefore, very rapidly consumed. Besides, if the bottom is to act as a second electrode, it is always in danger of being eaten through and allowing the iron to escape; in the case of a water-cooled bottom electrode this feature is doubly dangerous, for every foundryman knows what violent explosions take place if molten iron is brought into contact with water.

This is avoided in type (c) with two or more electrodes from above, in series; but here again the great consumption of electrodes is a very weighty matter, more especially as a furnace, to compete with a blast furnace, must have very heavy electrodes, up to 24 x 24 inches in section, by 5 to 6 ft. in length. Such carbon blocks are very costly and difficult to manage.

Now, one might suggest, as has indeed been already suggested, "why not place the carbons through the wall of the furnace"? This is all very well in theory, but will not work well in practice. First of all a good portion of the electrode is still brought into the hottest zone of the furnace, and exposed to the burning gases, which will attack them all the quicker because of the high temperature; secondly, almost all refractory material has the annoying property of becoming a good conductor at high temperature, and the current will therefore soon begin to flow through the furnace walls and rapidly destroy them. A water-jacket is again heat-wasting and highly dangerous.

For this reason experienced furnace designers have long ago realized that the electrodes must "burn free," i. e., must nowhere touch the furnace wall. Then again, the question of a suitable holder becomes a great difficulty and a source of endless trouble. Also, the proper regulation of the electrode is very difficult, surrounded as it is by the packing charge, not to speak of the possibilities (or impossibilities) of recovering the escaping gases.

One furnace has been proposed and tried, where the molten iron itself was collected in two grooves or hearths, each connected with one terminal, thus striking an arc or forming a resistance bridge by means of the charge. The two grooves were separated by means of a non-conducting partition, but soon after heating up this began to conduct, whereby the current simply took the shortest path and rapidly destroyed the partition, causing short-circuiting and leakage.

(2) The plain **induction furnace** as a smelting furnace.

This class of furnace has also been tried for the purpose, but owing to its nature, the circular hearth with a vital part, the primary coil, in the center, its application seems more than problematical. Besides, the source of the heat, although rightly placed at the bottom of the furnace, is in the molten iron itself, which thus has to be raised to a very high temperature, and it will be extremely difficult, if not impossible, to find a suitable lining to stand the strain.

(3) The **combined induction and resistance furnace.** (Röchling-Rodenhauser.)

This furnace may, at a first glance, seem to overcome some of the above difficulties, owing to the principal, large rectangular hearth in the middle, between the two energizing coils; but here again, the heat must only be generated in the bath of molten iron, with all the disadvantages of such a practice, and besides, we must remember that the "side plates," acting as secondary conductors, will be strongly attracted by the slag and fluxes necessary, so that in this case, with a strong reaction immediately above the bath (which of course must be of variable depth during the operation), the life of these "side plates" is not likely to be of any great length, although they have proved satisfactory in steel refining.

Finally, in all cases where a large current-density is required in the charge, the heavy conductors necessary form a very important and costly item, more so even in the case of an electric furnace.

It is certainly not our intention in this article to stamp the

[1] *Iron and Steel*, 1906, p. 30

[2] *Iron Trade Review*, 62, 25.

[3] See also the elaborate papers by F. du P. Thomson and A. J. Rossi in Electrochemical and Metallurgical Industry, vol. III, pp. 95, 150, 190. The latter gives the following summary of figures found by different investigators for the available electrical surplus energy per ton of iron; the higher figures are chiefly due to the greater amounts of coke per ton of iron on which the calculation is based: Greiner (2240 lb. coke per ton of iron), 800 hp-hours = 600 kw-hours; Uehling, 848 hp-hours = 636 kw-hours; Thomson (2240 lb. coke), 868 hp-hours = 651 kw-hours; Thomson (1700 lb. coke), 558 hp-hours = 419 kw-hours; Rossi for Gayley dry blast (1726 lb. coke), 724 hp-hours = 543 kw-hours. Mr. Harden's figure, given above, is based on 570 kg = 1254 lb. coal per ton of iron, and it will be seen that his calculation is decidedly on the safe side.—Editor.

electric smelting furnace as a hopeless impossibility—far from it; but it is only intended to state things *as they are at the present*, and keep some of those optimists a little nearer the earth who dream that the days of the good old blast furnace are doomed, and must give way to the more modern electric smelting. We certainly believe that the smelting furnace is capable of attaining perfection, like everything new, but all improvements must go steadily forward, not in leaps and bounds, as the effects of undue rashness are only leading us astray.

Now, *where* would it be justifiable to try electric smelting, even in spite of its higher cost? One might say, "If I need 400 kg coal in all cases for reduction alone, and only another 175 kg as fuel for each ton of iron, I might just as well spend these in a blast furnace, and do away with all the trouble of electric smelting!" That is so, but take a place like India, or the Western States of U. S. A., where practically no coke is to be had at the present, but with large deposits of cheap ores and abundant water power, especially if the latter is utilized for other purposes, giving an easy surplus at an extremely low cost per unit, available for electric smelting.

This is the right place for a plant of this kind, for wood and forest waste *may* be had in sufficient quantities to permit, by means of a good charcoal kiln, the production of charcoal for the reduction only, but no more; and this is the reason why we have only taken charcoal into consideration as a fuel. Besides, a well-managed charcoal kiln will give by-products of such value that a good portion of the charcoal is paid for by them, so that even under unfavorable conditions the cost of charcoal should not exceed $12, as stated before.

Dr. Neumann states[1] that charcoal may be used with satisfactory results in the electric smelting furnace, especially if it is in the form of briquettes, either by itself or together with the ore.

In the Lash process[2] we have a good example of such a method of operation. Here, iron ore, turnings, etc. (sweepings), and carbon in some forms, are briquetted and reduced, either in an open-hearth furnace or an electric smelting furnace. Tests are reported to show that this process may, although not cheaper than the blast furnace process, be quite justified and fairly economically worked in such cases where the production is not large enough to justify the erection of a blast furnace, and where a great economy in coal is necessary. In this way electric smelting may be employed as a profitable step toward the final perfection of the art.

LONDON, November, 1908.

LIST OF LITERATURE ON ELECTRIC SMELTING.

ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol. I, p. 460 (1903); Vol. II, pp. 475, 479 (1904); Vol. III, pp. 53, 150, 180, 190, 218 (1905); Vol. IV, pp. 84, 124, 129, 152, 164, 167, 231, 235, 265, 332, 441, 507 (1906); Vol. V, pp. 8, 24, 165, 298, 318, 367, 411, 445 (1907); Vol. VI, pp. 139, 163, 315, 326, 353, 493 (1908).

Report (1904) of Canadian Commission (E. Haanel) on European electrothermic processes for smelting iron ores.

Report (1907) of Canadian Commission (E. Haanel) on Sault Ste. Marie experiments with Héroult furnace.

B. Neumann, Elektrometallurgie des Eisens (Vol. XXVI of German monographs on applied electrochemistry).

A. Stansfield. The Electric Furnace.

Stassano Process:

Z. f. Elektrochemie, V, 379; VI, 221; VIII, 61, 852; IX, 555.

Elektrochem. Zeitsch., 1901, VIII, 16; 1905, X, 123, 168.

Jahrbuch für Electroch., 1899, 320, 552.

ELECTROCHEM. AND MET. INDUSTRY, I, 247; III, 391; IV, 167, and in great detail in VI, 315.

Elec. World and Eng., XXXVII, 737, 847.

L'Electrochem., 1899, VIII, 121.

L'Elettriciti, 1901, II, 161.

Stahl und Eisen, 1899, XVI, 727; 1904, Nos. 12 and 16.

Report of Canadian Commission (1904), pp. 11, 178.

Harmet Process:

El. World and Eng., XL, 765.

Berg. u. Hüttenm. Ztg., 1905, III, 39.

Eng. and Min. Journal, 75, 520.

ELECTROCHEM. AND MET. INDUSTRY, I, 422, 587, 588; II, 110, 503.

Héroult Process:

Z. f. Elektrochemie, 1903, No. 9, 556, 655.

ELECTROCHEM. AND MET. INDUSTRY, I, 449, 467; II, 408, 481; III, 155, 337, 447; IV, 84, 124, 152, 265, 332; V, 8, 291, 298, 318, 411; VI, 493.

Stahl und Eisen, 1902, 1105; 1904, Nos. 12, 16.

[1] *Elektrometallurgie des Eisens.*

[2] ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, vol. V, pp. 279, 322, 344, 378, 440, 455, 479, and vol. VI, p. 493.

The Electrolytic Reduction of Aluminium as a Laboratory Experiment.

BY M. DE KAY THOMPSON.

It is the object of the following paper to describe the difficulties encountered in attempting to electrolyze a solution of aluminium oxide in melted cryolite according to the Hall patent, and to show how they may be overcome to a certain extent. This experiment was first tried in the full expectation that the results obtained by Haber and Geipert[1] would be easily reproduced, but since, after numerous attempts, this was found to be impossible, it was thought an account of these experiments might be interesting to any who may have encountered the same difficulties.

The sources of electricity used in the following experiments were a 25-kilowatt transformer with variable voltage for melting up the cryolite at the start and a 25-kilowatt double-current generator for the electrolysis. The two windings of the armature of the generator could be connected in series, giving about 25 volts, or in parallel, giving half this voltage, or one winding could be left idle.

The chief difficulty with the experiment may now be described. If, after melting up, cryolite mixed with 20 per cent of its weight of aluminium oxide in an Acheson graphite crucible, the crucible forming one electrode, a graphite rod the other, the direct current is thrown on, at first a large current passes, but very soon drops nearly to zero. Simultaneously there is a peculiar effect at the anode, called hereafter the "anode effect." It seems that where it dips into the melted cryolite a film of gas covers it, insulating it from the cryolite.

This is similar to the effect observed by Wöhler[2] in the electrolysis of melted calcium chloride, with this difference in the case of cryolite, however, that opening and closing the circuit does not in any way eliminate it. The appearance of the molten salt not wetting the anode suggests its similiarity to the "spheroidal state." Of course the presence of gas at the anode is due to the liberation of oxygen from the alumina which combines with the carbon to form carbon monoxide or dioxide. The following experiment is given as an illustration:

EXPERIMENT I.

Anode.—Acheson graphite rod, 5 cm. diam.

Crucible.—Acheson graphite, 10 cm. inside diameter, 6 cm. depth, walls 1.75 cm. thick. Rests on graphite block, to which copper connections are screwed. The crucible was packed around with carbon held in place by asbestos boards.

Cryolite.—Natural cryolite mixed with 20 per cent of its weight of aluminium.

The cryolite was melted up with the alternating current and the direct thrown on.

[1] *Zeit für Elektrochemie*, Vol. 8, 1 (1902).

[2] *Zeit. für Elektrochemie*, Vol. 11, 616 (1905). This effect is not nearly so troublesome, if the anode surface is increased, as in the apparatus of J. H. Goodwin, *Proc. Am. Phil. Soc.*, Vol. 43, 381 (1904). Here the crucible is anode; a rod in the center is the cathode.

Temperature by a thermoelectric junction in a graphite tube.

Time.	Amperes.	Volts.	Temp.	Remarks.
3:03	270	12.0	910°	
3:05	250	13.0	910°	10 g. Al_2O_3 added.
3:06	180	....	....	
3:07	240	12.5	880°	
3:12	240	13.5	870°	10 g. Al_2O_3 added. Heated up with alternating current.
3:25	390	13.0	....	
3:29	300	11.8	....	
3:32	....	....	....	"Anode effect."

This experiment is characteristic of the way the electrolysis acts with this size crucible. From the fact that the alternating current had to be thrown on at one time in order to heat it up, it is evident that the power sent through the cell was not sufficient to keep it up to the necessary temperature. The same result is obtained with artificial cryolite made by mixing aluminium and sodium fluorides. The other experiments with this size crucible will be omitted, as similar results were obtained.

Next a crucible of exactly the dimensions used by Haber and Geipert was turned out of a graphite block. The diameter at the top was 138 mm, at the bottom 113 mm, and the depth, 70 mm. The electrode was 50 mm in diameter, as used previously. Natural cryolite was used, containing initially 10 per cent alumina.

EXPERIMENT 2.

Cryolite melted up and direct current applied.

Time.	Current.	Volts.	Remarks
12:46	300	12.0	
12:50	350	12.4	
12:55	270	....	
1:05	280	11.6	
1:10	280	11.8	
1:15	275	....	
1:20	275	15.0	"Anode effect."

Here fresh cryolite added, melted with the alternating current, and direct current applied.

Time.	Current.	Volts.	Remarks.
1:34	400	10.5	
1:37	400	10.5	
1:40	400	....	10 g. Al_2O_3 added.
1:42	400	11.0	" " "
1:53	400	....	" " "
2:05	100	12.7	" " "

"Anode effect." Here melted cryolite was ladled out and fresh cryolite melted up.

Time.	Current.	Volts.	Remarks.
2:30	400	11.0	
2:32	400	11.4	
2:35	400	11.4	"Anode effect."

Cryolite again removed and fresh put in its place.

Time.	Current.	Volts.	Remarks.
2:58	400	10.0	
3:00	350	9.9	
3:04	400	9.9	10 g. Al_2O_3 added.
3:06	400	11.0	
3:08	400	10.1	
3:10	400	11.1	
3:13	400	11.1	
3:20	400	11.1	

Fresh cryolite added.

Time.	Current.	Volts.	Remarks.
3:25	380	....	
3:35	380	....	"Anode effect."

76 grams of aluminium were ground in the crucible on cooling, corresponding to 36 per cent current efficiency.

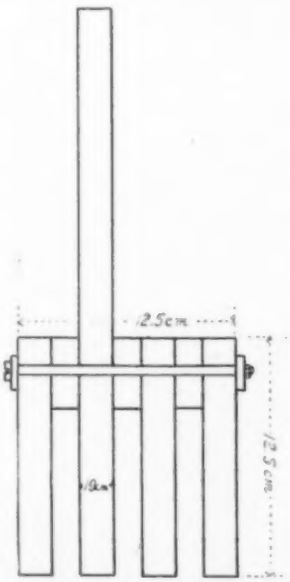
Evidently this was a slight improvement over the smaller crucible. It will be noticed that every time fresh cryolite was substituted for that already in the crucible, the electrolysis started up again for a short while. Changing the anode did not have this effect. The trouble, therefore, seems to be caused by some change that takes place in the solution electrolyzed. The contents of the crucible is always darkened after the run and smells a little of acetylene, showing the presence of carbide.

It was found that the addition of neither sodium fluoride nor aluminium fluoride had the effect of starting up the current in the way that natural cryolite did. A carbon anode was also tried, but with the result that the "anode effect" appeared even sooner than with graphite.

In another run similar to the one just given where the temperature was about 1100° with an anode the size of Haber and Geipert's, 66 mm in diameter, no better results were obtained. In this case the liquid gradually thickened up after electrolyzing half an hour, and the current gradually decreased, when finally the "anode effect" appeared. Thirty fine grams of aluminium, corresponding to 38 per cent current efficiency, were obtained in this run.

It will be observed that with the larger crucibles the runs were, in general, more successful than in smaller ones. This suggested the idea that if the crucibles were made large enough the difficulties found with the smaller sizes would disappear of themselves, and that a minimum size of cell might be found by trial in which the electrolysis would take place satisfactorily.

Accordingly a cell was made of graphite plates clamped together with iron bands and made tight with a paste of carbon flour, water and molasses. This was dried in the hot closet before using. The inside dimensions were 14 cm x 20 cm. The anode consisted of four graphite anodes 5 cm in diameter.



ELECTRODE CONSTRUCTION.

The "anode effect" appeared here as before, however, and 650 amp was the largest value of the current during a run This is evidently not much more than half that four electrodes should carry. Another trouble with this arrangement was that the cryolite was melted only around the anodes and gradually collected in the corners and solidified. However, more aluminium was obtained than in any of the previous cells.

Evidently the anode must be more uniformly distributed over the surface of the cathode so as to keep the cryolite melted in all parts of the box forming the cathode, it must have a large surface, and at the same time allow the gas to escape. These conditions, as well as having a somewhat greater cross-sectional area, are fulfilled by the anode shown in the accompanying figure.

It is seen to consist of four graphite plates 1.9 cm thick, in the form of a grid 12.5 cm in height, breadth and length. The cathode consists of a box 17.8 cm square made of graphite plates of the same thickness. The following experiment was carried out with this anode:

EXPERIMENT 3.

Time.	Current.	Volts.	Remarks.
1:35	....	....	Alternating current applied.
2:00	500	....	Direct current. Cryolite melted only under two plates.
2:02	550	10.7	
2:08	600	....	20 g. Al_2O_3 added.

2:15	670	....	
2:16	200	....	"Anode effect." 20 g. Al_2O_3 added.
2:20	600	....	
2:22	750	....	
2:23	850	10.0	20 g. Al_2O_3 added.
2:27	....	....	" " "
2:30	910	9.9	Cryolite now melted under three plates. 20 g. Al_2O_3 added.
2:34	950	....	
2:37	....	....	"Anode effect." 20 g. Al_2O_3.
2:39	1000	....	
2:41	1000	....	
2:45	....	....	"Anode effect." 20 g. Al_2O_3 added and current started up.
2:49	840	....	
2:50	....	....	20 g. Al_2O_3. Cryolite melted under all plates.
2:54	....	....	20 g. Al_2O_3.
2:56	....	....	"Anode effect."
2:58	900	....	Al_2O_3 added. "Anode effect" on some plates and not on others.
			"Anode effect" on some plates and not on others.
3:00	930	....	"Anode effect." 20 g. Al_2O_3.
3:06	1000	....	
3:08	....	....	20 g. Al_2O_3
3:12	1010	....	" "
3:14	....	....	" "
3:15	1000	10.0	
3:18	....	....	20 g. Al_2O_3.
3:21	950	....	" "
3:22	900	9.1	
3:23	....	....	20 g. Al_2O_3. Getting too hot; voltage lowered.
3:27	810	9.4	
3:33	....	....	20 g. Al_2O_3.
3:35	950	8.4	
3:37	....	....	20 g. Al_2O_3.
3:41	900	8.8	Electrolyte seems thicker.

Up to this point over 2 kg of cryolite had been melted up. A layer of aluminium had collected at one point about as deep as the cryolite, and this was burning up.

The experiment was therefore stopped here, as no more cryolite was on hand to melt up and cover the aluminium already obtained.

On cooling over night the graphite box was taken to pieces and 260 grams of aluminium were obtained, consisting of one large piece of about 220 grams and the rest in several smaller pieces.

This corresponds approximately to 49 per cent ampere-hour efficiency.

From this experiment it is seen that though the troublesome "anode effect" appears, it, nevertheless, does not prevent carrying out a satisfactory run. This seems to be due to the form of the anode as well as to the increased size of the cell. As is noted under the column headed "Remarks" the "anode effect" may appear on one part of the electrode and not on the other, and thus the electrolysis continues on the unaffected part while it is made to disappear on the other by adding aluminium oxide and stirring up the solution with a graphite or iron rod.

The current which passed was sufficient to keep the temperature up to the desired point with no other heat insulation than a single surrounding layer of firebrick. The temperature was not measured, but appeared to be about 1000° C.

Since the object of this work was simply to find a cell in which this reduction could be carried out on a small scale as a laboratory experiment, and since this object was accomplished, no further experiments were considered to be necessary.

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The Problem of Bearing Metals.

BY SAM. K. PATTESON.

One hundred and sixty-five million pounds of bearing metal is the amount that has been estimated to be in actual use on the railroads of this country, and when is added to this the metal which is used on engines, shafting, in rolling mills and machinery of all kinds, the total would in all probability considerably exceed $50,000,000.

The constant increase in the demand due to wear and necessary replacements makes the question of supply one of the greatest importance. In addition, the quality of the bearings affects very largely the life of the machine itself, and in view of all these facts the value of intelligent and scientific treatment of the subject cannot be overestimated.

The data available is surprisingly meagre under the circumstances, and in very few cases is the composition of the bearing metal sufficiently considered with reference to the requirements demanded. In some cases the metals have been manufactured under patents and sold under trade names, but in the majority of cases they are made of scrap with very little care exercised in seeing that the proportions of the different constituents are the correct ones.

Probably this lack of available data is not equalled in any other branch of engineering progress to-day. As a result the purchaser is compelled to take his bearing metal on faith, especially in view of the fact that in most cases, particularly in small shops, means and funds are not at hand to make accurate tests of their qualities. Only the largest consumers, as a general rule, have the necessary appliances and even when these are at hand, the special knowledge which is required to conduct the test is often unavailable. The only recourse of the average consumer, therefore, is to depend more or less on the reputation of the firm furnishing the material.

A considerable variety of metals, with a greater range in proportion of each, exists in metals used for bearings. Copper, lead, tin, antimony and zinc are combined to form what are known as Babbitt metals, after the name of the man who discovered the advantages of such a combination, white metal, brass, phosphorous bronze and various other trade names. A great majority of them are sold merely under trade names, and in many cases there is a considerable variety in their composition, even though of the same brand and sometimes in the same shipment. "Plastic bronze" and a few others are sold under patents, but these form a minority of the total.

Bearing metals should have sufficient strength to withstand considerable strain and enough resisting power not to crack or break when subjected to heavy and sudden shocks nor to be crushed by pressure. In the selection of a bearing metal, however, special attention should be given to the local requirements.

The temperature plays a very important part here. If the metal is subject to extremes of heat and cold, with resulting contraction and expansion, binding may occur to such an extent that breakage may result from this cause. Again, extremes in temperature affect very seriously the brittleness, ductility, etc., of the metal.

Chemical action upon the bearings will also often result in injury, and in establishments, such as ammonia refrigerating plants or chemical factories, this factor should be borne in mind. These local effects are probably most severe in electrical machinery, where the bearings themselves must serve as electrical conductors, as in trolley cars and like installations. Elimination of friction and resistance to compressive loads have supplied subjects for investigation in machinery progress probably more than any other.

Thurston claims that all metals have the same friction, and the value of the soft white alloys for bearings lies chiefly in their ready reduction to a smooth surface after any local injury which might result from the introduction of foreign matter between a bearing and the pulley or moving surface. The

injury is rapidly filled up by the metal flowing into it forming a larger area for the distribution of the pressure, and hence reducing the possibility of overheating, since the larger the bearing surface the less the likelihood of heating.

Hence, the lower the frictional properties of a bearing the less will be its compressive resistanee to shocks and invariably alloys best suited for bearings from an anti-frictional, and, hence, speed point of view are the least satisfactory for utilization in heavy machinery units. To overcome this difficulty an iron or steel grid has been recently introduced to form the base of the main bearing. This is filled with a much softer bearing metal than could be used under ordinary circumstances. This is a distinct step in the right direction and presents possibilities of great importance.

A number of metals possess good anti-frictional qualities, but lead is the first one on the list which is practically available, owing to the high cost of the others. Excluding, therefore, the costly ones, lead has the greatest anti-frictional properties of the available metals due to the fact that it flows more easily under pressure.

Lead, with the exception of iron, is the cheapest of the metals. The various metals suitable for use in the formation of bearing alloys are somewhat as follows:

Lead,	per	100	lb.....	$4.00
Zinc,	"	"	"	5.00
Copper,	"	"	"	13.00
Tin,	"	"	"	30.00, sometimes more.

Thus, the more lead a given bearing contains the softer it is, the better its anti-frictional qualities, and the cheaper it will be.

Lead cannot be used alone, however, as it cannot be retained in the recesses of the bearing, and various other metals have been alloyed with it, such as tin, antimony, copper, zinc, iron and a number of known metallic substances, such as sodium, phosphorus, carbon, etc.

Experiments with these different compounds have given a fairly adequate amount of data as to their varying effects. Thus, antimony and lead produce a hard and brittle alloy. If tin is added to this it is toughened to a considerable extent. These three constituents are most common in the various bearing metals on the market.

If the proportion of antimony is increased, better wearing qualities and greater compressive strength result, making it more suitable for heavy machinery. Less antimony and more lead form a combination which is especially suited for high speeds because of the better anti-frictional qualities of the lead. While the addition of tin will increase the toughness of the bearing, it will also considerably increase the cost.

The steady increase in speed in the development of modern machinery creates a wide range of duty for the bearing metal. The chief obstacle to the development of the modern turbine lies in the difficulty in securing proper bearing surfaces. Soft babbitts are required for high speeds, and soft babbitts will not stand the shock and strain of heavy machinery. On the other hand, the harder babbitts suitable for heavy machinery present too great frictional properties, and it can be said that on the solution of these problems depends the increase in size and speed of machinery to-day.

Another phase of the subject which has probably not received the attention which it seems to warrant is the effect of temperature on the bearing properties of the alloys. Means for maintaining proper temperatures would undoubtedly result in great improvement. This subject is being investigated more especially in regard to turbine construction, however, since the speed in this development made the bearing problem an acute one. In fact, the efficient operation of the turbine can be said to depend upon a satisfactory solution of this question.

The following table gives in a general way the composition of the bearing metals commonly found on the market to-day.

Alloys.	Lead.	Tin.	Anti-mony.	Copper.	Zinc.	Other constituents.
Babbitt 1	80.0	20.0	...	...	...	.....
Babbitt 2	72.0	21.0	7.0	...	...	.....
Babbitt 3	70.0	10.0	20.0	...	...	.....
Babbitt 4	80.5	11.5	7.5	0.5	...	.....
Babbitt 5	0.5	68.0	...	1.0	31.5	.....
Babbitt 6	...	20.0	...	...	80.0	.....
Babbitt 7	...	86.0	10.0	4.0	...	.....
White metal	82.0	...	12.0	6.0	...	.....
White brass	...	64.0	...	2.0	34.0	.....
"Magnolia metal"	80.0	4.75	15.0	trace	...	Bi = 0.25
Car brass lining	80.5	11.5	7.5	0.5	...	.....
"Ajax plastic bronze"	30.0	5.0	...	65.0	...	.....
"Ajax metal"	11.5	11.5	...	77.0	...	.....
P. R. R. car brass	15.0	8.0	...	77.0	...	.....
"S. bearing metal"	9.5	10.0	...	79.7	...	P = 0.80
"Delta metal"	5.1	2.4	...	92.4	...	Fe = 0.1
"Carmelia metal"	14.8	4.3	...	70.2	10.2	Fe = 0.5
Tempered lead	98.5	0.08	0.11	...	...	Na = 1.30

The above table shows a wide variation in the composition of the various babbitts. The babbitt metal originally put on the market was a very expensive material. The cost, however, has been greatly reduced.

The first metal on the list, 80 per cent lead, is not a very hard one, but one that is suitable for high speeds. Its melting point is about 500° Fahr. In a general way the properties of all bearing metals can be readily deduced from their melting points.

The second babbitt is somewhat harder, containing 7 per cent antimony, and a slightly larger per cent of tin than the first. These two babbitts are favorites for lining purposes.

The fourth babbitt contains 20 per cent antimony and is still harder. It is suitable for heavy machinery and is widely used for that purpose.

No. 6 has good wearing qualities, but is too hard for high speeds. In fact, all the babbitts will give satisfactory results in the positions for which they are especially suitable.

The white alloys possess a fairly good electrical conductivity. Tempered lead is harder than pure lead, but its anti-frictional qualities are supposed to be great, owing to a somewhat novel development. In operation the caustic soda formed by oxidation of the sodium in the bearing metal saponifies with the oil and thus assists lubrication. The extent to which this phenomenon affects beneficially the operation of the bearing has not been determined.

The other alloys given contain varying proportions of copper, tin, and lead, and when lined with a thin layer of lead or some soft babbitt, wear much better than the softer metals. A large percentage of lead in an alloy tends to decrease the frictional effects, but pure lead is too soft to be used alone, and a certain proportion of other material is necessary.

The addition of tin increases the frictional effects and also increases the wearing qualities. Pure copper itself is so tenacious that it is practically impossible to work it with any tools without prior treatment and this property affects the bearing quality of any allow of which it forms a part.

The above gives a general review of the bearing metal situation as it exists to-day. The possible variations in the composition of bearing metals are innumerable. Comparatively little data is available on this subject. A large number of metals, such as calcium, have been recently placed on the market, many of which possess very suitable properties for bearing metals, and this development is bound to influence the situation.

Interest is increasing in the scientific solution of the problem and various improvements along various lines may be looked for in the near future. Such devices as the steel grid and similar developments are steps in the right direction and will undoubtedly aid in the solution of the problem.

Perkin Medal.

The Perkin Medal Committee has awarded the medal for the year 1909 to Dr. Arno Behr, Pasadena, Cal., for his valuable work in the glucose industry. The official award will be made at the January meeting of the New York section.

The Thermal Production of Ozone.

BY ARTHUR W. EWELL.

Franz Fischer, of Berlin, has recently demonstrated that ozone is produced when oxygen is raised to a high temperature. His methods have not as yet reached the high efficiency obtained by other processes, but the work is very promising. Fischer has shown his own belief in the ultimate success of thermal production by securing a broad patent covering such processes, and this patent has apparently been transferred to the Allgemeine Elektricitäts Gesellshaft[1].

The subject is particularly interesting to students of physical chemistry, because it illustrates the frequent ultimate technical value of experimental and mathematical investigations, which, by themselves, appear only of theoretical importance.

Some five years ago, at a scientific gathering at Cassel, Nernst announced that the equilibrium concentration of ozone increased with the temperature and that he had calculated the normal concentration to be as follows[2]:

Temperature Centigrade	1910	2957	6367
Concentration of Ozone (per cent)....	0.1	1	10

That is, for every 1000 grams of oxygen at 1910 degrees, there will normally be one gram of ozone.

It is not difficult to see how these figures were obtained. Suppose a mass of oxygen is allowed to remain under constant conditions a sufficient time for the equilibrium amount to be transformed into ozone. Let us calculate the difference of potential between the ozone and the oxygen, for, in general, two dissimilar bodies, in contact and in equilibrium, will be at different electrical potentials. Berthelet[3] found that 29,600 calories were required to form one gram-molecule of ozone from oxygen. If this potential energy were completely transformed into electrical energy we should have

$$4.19 \times 29.600 = 2 \times 96,500 \times E$$

where $2 \times 96,500$ is the quantity of electricity associated with one gram-molecule, 4.19 is the factor to change calories to joules, and E is the above natural difference of potential. Solving, we find E is 0.64 volt.

Grafenberg[4] and Luther[5] have measured the difference of potential between a platinum electrode which has absorbed ozone and one which contained hydrogen, and also the minimum potential required to liberate ozone in electrolysis. After allowing for the difference of potential of the hydrogen electrode, their results agree quite closely with 0.64.

If we regard this natural difference of potential as due to the difference in concentrations of the ions in oxygen and ozone, we may employ Nernst's concentration equation:

$$E = \frac{R\,T}{e}\,ln\,\frac{c_1}{c_2}$$

where R is the gas constant, 1.98 joules, T is the absolute temperature, e is the charge associated with one gram-molecule, c_1 is the concentration in the oxygen and c_2 is the concentration in the ozone.

We will assume further that the heat of formation of ozone varies little with the temperature, i. e., that E is constant, and that the concentration of the ions in the two gases is proportional to the concentration of the gases. Hence, changing to common logarithms, we have:

$$0.64 = \frac{1.98 \times 2.30}{2 \times 96,500}\,T \log\,\frac{c_1}{c_2}$$

If we substitute $c_1/c_2 = 100$, T comes out 3230, or 2957 degrees Cen., and the two other results in the above table are similarly obtained. (I the equations above are examined, it will be noticed that the charge, which is assumed as two faradays, cancels out. Great importance should not, however, be given the results in the above table, on account of possible inaccuracy in Berthelot's work and uncertainty regarding the hydrogen electrode.)

Dr. Clement[6], working under Nernst, attempted to obtain ozone by heating oxygen to high temperatures. He obtained a gas which set free iodine and which shows other resemblances to ozone, but upon testing with tetrabase paper[7] he always obtained the yellow color characteristic of oxides of nitrogen, and never the violet color which characterizes ozone.

Nernst attributed his failure, not to incorrect theory, but to insufficient rapidity of cooling. If the mixture of ozone and oxygen, which is stable at a high temperature, is cooled suddenly to a low temperature, it remains at practically the same composition. For, although at ordinary temperatures the equilibrium concentration of ozone is almost infinitesimal, yet the decomposition toward this concentration is exceedingly slow compared with the rapidity with which the equilibrium concentration is reached at higher temperatures. If the ozone and oxygen are not removed almost instantaneously from the high temperature region, the product obtained will correspond to a comparatively low temperature, and the content of ozone will be inappreciable.

The equilibrium between ozone and oxygen subjected to the silent discharge is totally different. Warburg[8] has shown that here the equilibrium concentration of ozone increases with decrease of temperature. Briner and Durand[9] obtained pure ozone by means of the silent discharge at the temperature of liquid air.

It is unfortunate that we cannot analyze the gas at high temperatures. The change of volume corresponding to the formation of ozone is too small to measure accurately. Warburg's beautiful work upon absorption spectra suggests that possibly some information might be obtained by this means.[10]

Franz Fischer repeated Clement's work in the chemical laboratory of the University of Berlin, with such modification as would give a greater velocity of cooling.[11] He tried first various flames (hydrogen, acetylene, etc.) over liquid air or oxygen. Ozone was always found dissolved in the liquid, and with liquid air solid crystals of oxides of nitrogen were also formed. Next platinum was maintained at incandescence in liquid air or oxygen, and traces of ozone were found, although the experiments were somewhat unsatisfactory on account of the rapid destruction of the platinum.

An electric arc was maintained in liquid air and ozone was found, either dissolved or as dark blue globules. Finally, a Nernst glower was heated to normal brilliancy in liquid air or oxygen and a large amount of ozone was obtained.

The expense and inconvenience of using liquid air or oxygen led Fisher to seek a more practical method.[12] Clement's experiments, where oxygen traversed incandescent bodies, were repeated with far higher velocities. The maximum velocity used by Clement was 1 m. per second. Fischer worked up to 90 m. per second. The air or oxygen emerged from a slit a few tenths of a millimeter wide and impinged upon a Nernst glower a few millimeters from the slit. The heated gases then entered a glass tube surrounded by cold water.

When the velocity was less than 5 m. per second, no ozone was formed, but a large amount of oxides of nitrogen was produced. As the gas velocity was increased, an increasing yield of ozone was obtained, at 7 m. per second the ozone began to predominate, and at 30 m. per second no nitrogen oxide could be detected. Therefore, both the formation and the decomposition of ozone are more rapid than that of oxides of nitrogen. If the velocity was too great, e. g., 76 m. per second for a 0.1 mm slit, the ozone has insufficient time to reach the equilibrium concentration, and the yield decreases.

The highest concentration and the greatest efficiency were

[1] *Journal Soc. Chem. Ind.*, 1907, pp. 608, 872.
[2] *Zeit. für Elektrochemie*, 1903, 7, p. 891.
[3] *Comptes Rendus*, 82, p. 1281.
[4] *Zeit. für anorgan. Chemie*, 36, p. 355.
[5] *Zeit. für Elektrochemie*, 2, p. 832.
[6] *Ann. der Physik*, 1904, 14, p. 343.
[7] Arnold and Mentzel, *Central-Blatt*, 1902, 2, p. 1240.
[8] *Ann. der Physik*, 1902, 9, 1286; 13, 1080.
[9] *Comptes Rendus*, 145, 127.
[10] *Preuss. Akad.*, 1908, 6, 148.
[11] *Berichte deutsch. chem. Gesell.*, 39, 940-968.
[12] *Berichte*, 39, 2557-2566, 3631-3648; 40, 443-458, 1111-1120.

obtained with a velocity of 57 m. per second (1-mm slit) and the highest feasible temperature, 1930° C. Under these conditions 3.60 mg of ozone were produced in 160 seconds in 10 liters of air. The concentration was, therefore, 0.029 per cent by weight, or 0.126 per cent of the atmospheric oxygen. The Nernst glower required 0.50 amp at 123.5 volts. The commercial efficiency, or the yield in grams per kw-hour, was, therefore,

$$\frac{0.0036 \times 3600 \times 1000}{0.5 \times 123.5 \times 160} = 1.3$$

If, instead of air, 92 per cent oxygen was used, the percentage of oxygen changed to ozone was much less, under similar conditions, but the commercial efficiency was a little higher. In the earlier experiments, where the cooling was accelerated by the use of liquid air, a commercial efficiency of 3.5 grams of ozone per kw-hour was obtained for a concentration of 0.12 per cent and 2 grams for a 1 per cent concentration.

Let us compare these yields with those obtained by the silent discharge at ordinary temperatures[4] and by electrolysis.[2]

YIELD IN GRAMS PER KW-HOUR.

Concentration (gr. per cu. m.)	Thermal (blast)	Thermal (liq. air)	Electro-lysis	Points +	Points —	Dielectric
.37	1.3	...	..	60	40	70
1.8	...	3.5	..	50	37	55
14.	...	2.	..	..	10	..
290.	..	...	70	..	..	..

Therefore, at present the thermal production of ozone is relatively inefficient, but when it has received as much attention as has been devoted to the other methods, great improvements may be expected.

Many of the above phenomena may easily be shown in a lecture room. Remove the outer casing from a single glower Nernst lamp. Procure a seamless brass tube about 6 mm internal diameter and 1 cm external diameter, crush one end together and file away until there is a straight slit about 0.1 mm wide and 1 cm long. File away one side almost to the slit, so that it can be brought close to one of the heating tubes, and about 2 mm from the glower. By means of an ordinary foot-bellows drive a current of air through the slit upon the incandescent glower. The odor of ozone or oxides of nitrogen will soon be evident, and may be demonstrated to a class by holding in front of the blast and as close as possible to the glower, a paper saturated with starch iodine solution. The characteristic blue color will soon appear.

Since the yield of ozone decreases greatly with increase of moisture,[3] it will be of advantage to dry the air between the bellows and the slit by passage through calcium chloride tubes. A tube filled with glass wool next the slit prevents clogging by foreign particles. If a manometer is inserted, next the slit, the velocity of the air may be calculated from the formula $v = \sqrt{2p/d}$, where p is the pressure in dynes per square centimeter, and d is the density.

An organic chemist can readily prepare tetramethyl-*p*-*p'*-diamino-diphenylmethane (tetrabase). A paper soaked with an alcoholic solution, held in the blast close to the glower, will turn yellow at low velocities, and at high velocities a bluish violet, the former signifying oxides of nitrogen and the latter ozone. The starch iodine paper turns blue with both.

If the drying tubes are replaced by a gas washing bottle containing water, the tetrabase paper will not be affected, showing the absence of ozone and oxides of nitrogen. Starch iodine paper will be colored to practically the same degree as before, because hydrogen peroxide is now produced in considerable amount.[4]

Worcester Polytechnic Institute.

December, 1908.

[1]Warburg, *Ann. der Physik*, 1906, 9, p. 734. Ewell, *Phys. Rev.*, 1906, February, p. 3; April, p. 232. *Am. Journal of Sc.*, 1906, November, p. 368. *Phys. Zeit.*, 1906, 25, p. 927. This journal, 1907, July, p. 264.

[2]*Zeit. anorgan. Chemie*, 1907, 52, p. 229.

[3]*Berichte*, 1906, 39, p. 3631.

[4]*Berichte*, 1908, 6, p. 945.

Silundum, a New Product of the Electric Furnace.

By F. Bölling.

Moissan describes in his well-known book on the electric furnace a test made by him, as follows:

"Ces tubes de charbon ont le grave inconvenient de presenter une porosité notable; nous avons cherché à l'eviter le plus possible, en employant des tubes doubles ou des tubes recouvert de magnesie. Tous les essais tentés pour foudre à leur surface une couverte de silicure de carbon, de borure de carbon, ou d'autres carbures, ont été infructueux. Nous poursouvions cependant ces études, car il est très utile pour les récherches délicates qui restent à entreprendre aux temperatures élevées de preparer des tubes d'une etanchété parfaite."

Moissan intended to cover a tube of carbon with a layer of silicon carbide (carborundum). His purpose was to obtain a gas-tight tube, assuming that silicon carbide could be melted, while in reality this material behaves in this respect like carbon. Supposing that Moissan had obtained a deposit as desired, he would have found it to be as porous as the carbon.

I have referred to Moissan, for if he had succeeded he would have been able to produce years ago the material which is the subject-matter of the present article.

Since 1900 the writer occupied himself with the use of silicon carbide for resistances that would stand very high temperatures. Many experiments were made, mixing silicon carbide powder with bonds of the various compositions to bind the individual crystals of the powder together. These bonds were non-conductors at low temperatures, but at about 700-800° C. the bond and with it the entire resistance body became conductive, with the result that the resistances could not be used for very high temperatures. The experiments were suspended, but taken up again in 1904, with the result that a procedure was worked out and patented, by which it is possible *to convert any piece of carbon, for instance, in form of rods, bricks, crucibles, into silicon carbide.* Resistances are thus obtained that have no binding materials and will stand temperatures as high as 1650-1700° C.

Silicon carbide was known so far only in the amorphous or crystalline state, and it was supposed that it was formed by the sublimation of carbon and silicon. The writer, however, discovered *that silicon penetrates into carbon when both are in a highly heated condition.* The silicon at about 1600° C. exists only in the form of vapor, while the carbon at this temperature keeps its shape, it being understood that air has access neither to the one nor the other.

Silundum, as the new material has been named, or silicified carbon, is therefore *a product that is obtained when carbon is heated in a vapor of silicon.*

For the production of this material electric furnaces are used, of the same kind as for the manufacture of carborundum. The pieces of carbon of the various shapes are introduced into a mixture of sand and carbon, that is acted upon by a granular core of coke as conductor for the electric current. Instead of sand and carbon, amorphous carborundum can be used, enriched with sand, to provide for the necessary silicon for the carbon pieces to be converted into silundum.

The silicification of the carbon depends on the time and the temperature employed. It is possible to entirely silicify the carbon pieces or to cover them only with a layer of silundum.

This layer may be of any thickness desired. The shape of the carbon article acted upon remains entirely unchanged. It leaves the furnace in the same shape as it was introduced, and manufacturing marks that are pressed on the carbon remain distinctly visible. Tubes of carbon can be silicified inside and outside. Silundum tubes of any thickness of wall and of any diameters, as obtainable from carbon manufactures, are made in silicifying a solid carbon rod, leaving a core of carbon inside, which is burned away in a furnace, which communicates with

the air, leaving thus a tube of silundum. It is possible to make round, square or flat tubes.

If it is desired that one part of the carbon piece remains carbon on one spot, this place is shielded by another piece of carbon, thus preventing the silicon from penetrating into that particular spot. Lamp filaments can be easily converted into silundum or only covered with a layer of silicon carbide. Charcoal is very easily converted into silundum; so is coke, because both are very porous.

The silicification takes place easier with porous carbon pieces than with pieces that are pressed very hard and tight and baked. Graphite is easily silicified. Carbon powder compressed at very high pressure can be silicified without being baked first. In order to accelerate the process of silicification, the pieces can be made of carbon and amorphous or crystalline carborundum, bound together with tar or any other bond that contains carbon.

This modification may be used in cases where very large pieces, bricks or the like, are to be converted into silundum.

Instead of using carbon and sand or amorphous carborundum and sand, the pieces could eventually be laid in molten silicon. It is quite natural to think of this means to convert the carbon pieces into silundum, but, as it is cheaper and easier to obtain the necessary silicon from the sand, this idea was abandoned.

For the production of this material cheap current is desirable, at least for larger pieces, while the price of the electric energy is of not so great importance, where smaller rods up to four or five millimeters diameter come into consideration. The material is produced at present in a plant in Switzerland that has been erected for this purpose.

PROPERTIES OF SILUNDUM.

Silundum is another form of silicon carbide and it has generally the same properties. It is very hard; it resists temperatures up to about 1600° C. when heated in air and does not oxidize. It resists the attack of acids when cold and is a conductor of electricity, its resistance being several times that of carbon.

The hardness of silundum is variable and depends on the zone around the core of the furnace in which it is produced. Material from the amorphous zone is less hard than that obtained in the crystalline zone. It may be assumed that the hardness depends on the temperature in which the material is produced. The hardness may also depend on the amount of silicon taken up by the carbon. It seems that some pieces contain more or less silicon than others, but no analysis was made to ascertain this.

In regard to the fireproof qualities of silundum, it may be mentioned that at about 1700° C. the silicon leaves the carbon and combines with the oxygen of the air. Small transparent globules are formed (for instance, on a rod that is put in a circuit and heated to about 1700° by the electric current) on the surface, of clear or brownish color. These globules are silicon dioxide. Parts of the silicon escapes in form of a white vapor.

Silundum cannot be melted, and it behaves in this respect like carbon. The electric resistance of silundum is variable and depends on the kind of carbon and its hardness. Silundum made from porous carbon has a higher resistance than when made of hard carbon. The resistance depends also on the modification of the material. If produced in the amorphous zone the resistance is generally higher than in the crystalline zone.

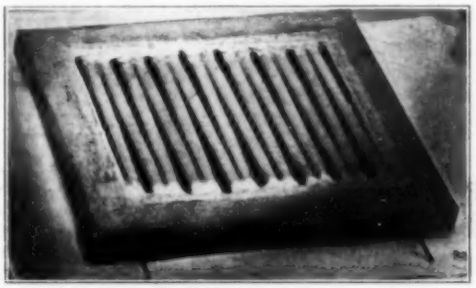
USES OF SILUNDUM.

The first use for which the material found application was for electric cooking and heating purposes. For this use the experiments that led to the invention were made.

The electric heating industry for domestic as well as for industrial purposes demands, for a large number of appliances, a higher temperature than can be obtained by ordinary resistance wires. Platinum, of course, can be used, but this material is very expensive, especially so when thick wires or ribbons are used, as should be done, of sufficient mechanical strength. Silundum replaces platinum for this purpose and is much cheaper.

Electric cooking and heating industries have developed in the last five years enormously and will continue to do so. Any reduction in the price of electric energy will result in a greater demand for electric ranges, which may be used for cooking just like gas ranges. The electric range demands, however, a concentration of electric energy to be converted into heat that can hardly be obtained at present with any system without overheating the resistors or without increasing the weight of the heating plate, with the result that the preparation of a meal requires too much time, in comparison with heating by gas or coal. Silundum stands very high heat, does not oxidize and can be used with the necessary high temperature needed for the purpose. Ranges are produced that have the glowing heat of a coal fire and they are used exactly as those heated by coal.

For industrial purposes there is a large field for heating apparatus for melting metals, brass, aluminium, lead, tin, etc., and for electric laboratory ovens for high temperatures, and it is especially for this purpose that the material fills a long-felt want. Platinum and platinum-iridium has been used to a great extent for laboratoy ovens, but such apparatus are very expensive and they can be repaired only at great expense.



SILUNDUM.

Silundum can be used with just as high temperatures as platinum and its price is low. The first cost of the apparatus as well as the expense for repairs are considerably lower than with platinum.

For heating purposes the silundum rods can be used single in lengths up to 800 mm, depending, of course, on the diameter, as solid, round, flat or square rods or tubes or also, as shown in the adjoining illustration, made into grids, mounted in a frame and provided with contact wires. The purpose of the present article is not to show the numerous constructions of electric heating apparatus that have been and are made with silundum, but only to describe the material and its uses.

Silundum stands just as well as silicon carbide the attack of acids, and experiments are now being made to use it as electrodes for electric bleaching purposes instead of platinum-iridium, carbon or graphite. In order to prevent the oxidation of carbon electrodes used for the manufacture of ferrosilicon, it has been proposed to cover these electrodes with a layer of silundum.

Silundum can be nickel plated or covered with a layer of platinum.

Silundum is a very refractory material and does not melt. It is, however, attacked at high temperatures by molten metals, but this should not prevent its use as fireproof material, for it is easily possible to cover the outside of a carbon or graphite crucible or the like with silundum and leave the inside carbon. It is not necessary to silicify pieces to be used for fireproof purposes entirely, but only to a certain depth and according to the use for which they are to be employed. Carbon bricks or any shaped pieces can be covered with a layer of silundum at small cost. It is thus possible to obtain a material that for many purposes will be far superior to any fireproof material known so far.

Silicified coke can be used instead of ferrosilicon or carborundum in the steel industries, and, as it can be produced at very low cost, it will doubtless find extended application.

In conclusion, I may say that I have tried carbon filaments covered with silundum and filaments entirely converted into silundum, but found that when used in a vacuum the globes soon were covered with a brownish or black layer, very likely of silicon. I may also add that if a carbon filament is first silicified and the silicon driven out again by overheating it a graphite filament remains that has very valuable qualities.

Frankfort-on-the-Main, Germany.

Three New British Aluminium Works.

The present crisis in the aluminium industry and the fall of the price of aluminium in London to the level of copper has been chiefly due to outsiders entering the field of aluminium manufacture in various European countries and crossing the purposes of the formerly almighty international syndicate, which has now been dissolved. While these new works of the independents were opened, the old syndicate plants also made very considerable extensions. This resulted in overproduction, which was further accentuated by a reduced demand due to last year's industrial crisis. The present situation in the aluminium industry is the natural outcome.

A description of two new aluminium plants, erected by the Aluminium Corporation, Ltd., in Great Britain (a new company outside of the old syndicate), and of a large new works of the British Aluminium Co. (a member of the old syndicate) is, therefore, of timely interest. The following description has been prepared from articles in the (London) *Electrical Review* of Nov. 6, the (London) *Electrical Engineering* of Nov. 17, and the (London) *Electrician* of Dec. 4, as well as from private information received from British correspondents.

FIG. 1.—ALUMINIUM PLANT, DOLGARROG.

Dolgarrog Works.

One of the new works of the Aluminium Corporation, Ltd., is located at Dolgarrog, six or seven miles from Conway, in North Wales. The principal source of electric power is a water falls with a head of over 1000 ft., and a supplementary supply of power is obtained from a high-voltage transmission line of a power company.

The power plant contains four Pelton wheels, each coupled directly to two 500-kw direct-current generators. The two machines of each set are connected permanently in parallel and the total output per set is 8000 amp at voltages varying up to 125 volts. In addition, the station contains two motor-generators which change the alternating current of the transmission lines into direct current. The motor half of each set is a three-phase induction motor, while the generator half of each set consists of two 300-kw direct-current generators. The total available power of the plant is, therefore, 5200 kw.

Immediately behind the power house in the same structure, but separated from it by a wall, are six bays, five of which contain the aluminium tanks or electrolytic furnaces, while the remaining bay is devoted to the recasting of aluminium ingots into the various forms required by commerce and to storage purposes. There is a total of 125 aluminium furnaces in these works, whose aggregate capacity is about 1600 tons of metal per year.

FIG. 2.—CARBON WORKS, WALLSEND.

The continuous nature of the work imposed on the electrical plant by the requirements of the electrolytic process rendered it necessary to build the dynamos in accordance with very stringent conditions. In the first place, precautions had to be taken against the unfavorable climatic conditions; for the greater part of the year it rains heavily, and the atmosphere, in consequence, is extremely damp.

The four dynamos have to run day and night at their full rated capacity of 8000 amp. At starting, the pressure is gradually raised from 0 to 40 volts, when the furnaces are switched in. Between 40 and 138 volts the regulation has to be so fine that the pressure can be raised volt by volt.

The normal pressure of the dynamos when running at 450 revolutions per minute is 125 volts, but the machines, even when hot, can give a pressure of 138 volts with a current of 8000 amp each for one hour. Moreover, they can give any current between 0 and 8000 amp at any pressure between 0 and 138 volts, with absolutely sparkless commutation, after 24 hours' run on full load.

The furnace room is lofty and well lighted, and is some 200 ft. long by 160 ft. wide. Along the wall immediately adjacent to the generating sets runs a pair of copper busbars 8 sq. in. in section. These bars are only intended to be used occasionally as "hospital-bars," or for coupling together any desired machine or furnace circuit.

Ordinarily, each line of furnaces will be fed from its own machine through massive connections coming direct through the wall. These main connections are each of 16 sq. in. section aluminium, built up of eight bars, each 4 in. by ½ in. From each of these, a set of eight 1-sq. in. flexible copper cables lead to the furnaces. These are arranged in groups of 25 connected in series, and taking a working current of about 7500 amp, but the groups can, of course, be subdivided if required. Five such groups will eventually be installed, and of these three are already erected.

Thus, when working at full power, each water-driven machine will run one group of 25 furnaces with a pressure of from 120 to 130 volts, across the terminals of the group, while the remaining group of 18 furnaces will be run off one of the motor-generators, which work only up to 75 volts. In practice, however, various other combinations can be made.

The behavior of each furnace can be studied by means of a conspicuous low-reading voltmeter, with which each is provided, and which indicates the voltage drop across the terminals of the furnace. (These low-reading voltmeters are a

substitute for low-voltage incandescent lamps used elsewhere. Such lamps connected across the tanks or furnaces are dark as long as the voltage is so low as to correspond to the proper decomposition of the alumina dissolved in the bath. When the alumina is used up, the voltage rises and the lamp lights up, indicating to the workingmen the necessity of adding more alumina.)

Wallsend Works.

It is possible that the Dolgarrog works would have attained more than their present importance, had not the company received from the district of Newcastle-upon-Tyne such favorable proposals and terms for electric power supply that it was decided to erect a second plant at Wallsend, not far from the Carville generating station of the Newcastle-upon-Tyne Electric Supply Co., Ltd.

FIG. 3.—PRELIMINARY MINING WORKS AT ST. BARNABE BAUXITE MINE.

An area of about 3½ acres, adjacent to the water front of the river, was taken and cleared of existing buildings, the foundations of the aluminium works and of a plant for the manufacture of carbon electrodes being laid in August, 1907. The work proceeded with such speed that at the end of February of 1908 the carbon works were in full operation, while the first metal was run from the aluminium furnaces on March 11.

Electrode Plant.—In order to obtain an idea of the arrangement of the works it is necessary to start with the carbon works, where the electrodes to be afterwards used in the furnaces are made. The raw materials used are oil, coke, retort carbon and pitch. These are brought to the works by water and are placed in a store adjacent to the wharf, capable of holding 200 tons of coke.

The oil coke is first calcined and then, together with the retort carbon, is passed through crushing machinery and reduced to a fine powder. This is then taken to mixers and incorporated with heated pitch in a liquid condition, afterward being placed under hydraulic pressure of 1 ton per square inch, and pressed into carbon blocks. The mixing machines and rams were made by Messrs. Wilson & Sons, of Johnstone, N. B.

The opportunity is taken in this process of inserting the iron bar which is to form the contact of the electrode in the furnace. These blocks of carbon, measuring approximately 10 in. x 10 in. x 12 in., are then placed in batches on trucks 6 ft. long and put into carbonizing furnaces, through which the trucks are gradually pushed forward by means of hydraulic rams, one truck pushing another till the complete passage has been made, taking a week or ten days.

The furnaces are three in number, each of about 4 to 5 tons capacity per day, and are each 190 ft. long, in the form of a horizontal kiln or flue, heated by means of producer gas. For this purpose three Dawson gas producers, with the necessary auxiliary plant, are installed.

After the trucks have passed through the furnaces they emerge into a cooling room, where the trucks are cooled down to a reasonable extent, and the baked carbon blocks are taken off and stored. Provision has been made to manufacture electrodes up to 5 ft. long, and powerful plant is installed for the purpose. In these carbon works the electrodes are made for both the Wallsend and the Dolgarrog works.

Aluminium Furnaces.—The manufacture of aluminium depends upon electrolysis at a temperature of 900° to 1000° C. of a bath consisting of alumina (Al_2O_3) dissolved in cryolite, a double fluoride of sodium and aluminium ($Al_2Fl_6.6\,NaFl$).

The alumina is at present obtained by the Aluminium Corporation in the open market; but before very long refined bauxite will be prepared by an affiliated company, the Bauxite Refining Co., Ltd., of Hebburn-on-Tyne, reference to whose operations will be made below.

Electric power is obtained from the Newcastle-upon-Tyne Electric Supply Co., Ltd., to the extent of 4000 kw, the supply being brought direct from Carville at 6000 volts to the substation on the works; a single-unit system feeding to the machines has been adhered to, with provision for coupling the feeders across in the substation.

This substation is arranged with reference to the furnace room precisely as at Dolgarrog. Four bays in the furnace room, which are 133 ft. wide and 160 ft. long, stand at right angles to, and are separted by, a wall from the power station, where are installed the motor-generators. The capacity of the aluminium furnaces installed is about 1000 tons of metallic aluminium per year.

In addition to this, furnaces are now erected for the manufacture of ferro alloys, such as ferrochrome of various grades, ferrosilicon, etc., and also electric steel. These processes are believed to lend themselves especially well to the electrochemical operations of the firm, and the furnaces now being built are more powerful than the aluminium furnaces, the power required for each varying from 400 hp to 1200 hp. The furnace room and power house stand on rising ground, so a lift has been installed for the transport of material to and from the furnace room. (The fact that these works are taking up the manufacture of ferro-alloys is perhaps significant. The same development took place some years ago when the calcium-carbide boom collapsed in Europe and carbide plants stood idle. But at that time manufacture of ferro-alloys was virgin soil.)

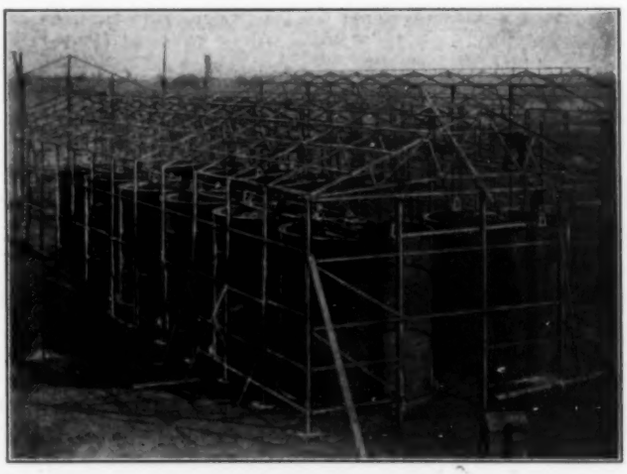


FIG. 4.—HEPBURN WORKS (FILTER PRESSES AND CONSTRUCTIONAL WORK).

After the aluminium metal has been run out of the furnaces into molds in the form of crude product ingots, these are passed to the stores; afterward they are taken to the recasting shop, where they are cast into the various market products, such as large bars in various sizes, billets for drawing into wire or rolling into rods, and tube billets for drawing into tubes. These special forms are made up as the order comes along, stock being usually kept in the form of ingots.

The recasting and alloy room contains three furnaces of special design, two being rotating furnaces with natural

draught, fired by producer gas, and the other being a tilting furnace by the Morgan Crucible Co., Ltd., for alloys, the blast being obtained by a motor-driven fan.

All classes of aluminium alloys are here produced for casting, rolling and general work, including aluminium bronze. Two of the most useful of the series are the Aluminium Corporation's "D alloy" and "F alloy." The former is an aluminium, zinc and copper alloy, giving a white casting metal that flows well and gives clean, sharp castings. It is used for motor fittings that have to be machined, and is especially good in sand or chilled molds. The latter is a copper-aluminium alloy much used for motor and cycle castings, being capable of bending and riveting cold.

At the Wallsend works is situated the chemical laboratory in which samples of all raw and finished materials handled by the

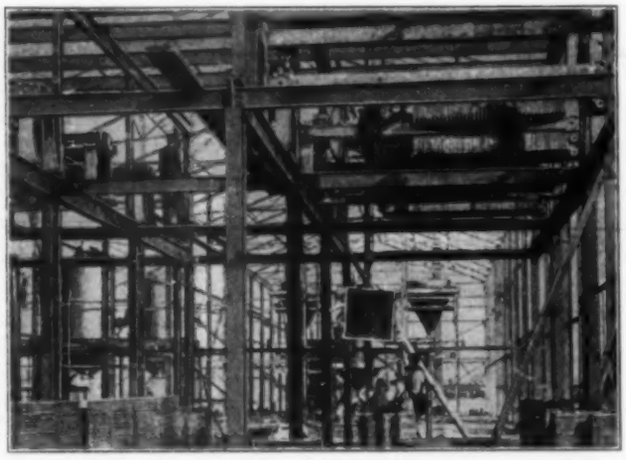


FIG. 5.—PORTION OF HEPBURN WORKS, IN COURSE OF CONSTRUCTION.

corporation are tested. The aluminium produced is of very high quality, in no case falling below 99 per cent of the pure metal.

Bauxite Works.—As noticed above, the Aluminium Corporation is about to obtain its alumina from an affiliated concern in Hebburn. The works of the Bauxite Refining Co., Ltd., which are just nearing completion, will be capable of turning out from 4000 to 6000 tons of alumina or refined bauxite per year, but are being designed so that their output can be doubled when required. In view of the present low price of aluminium it is of greatest importance to secure a supply of refined bauxite at the lowest possible rates.

The Aluminium Corporation have achieved this by obtaining valuable properties in the Var district, in the south of France, where the best quality of bauxite, containing about 62 per cent of alumina and a very low proportion of silica, is found. They have at present in operation two bauxite shafts at St. Barnabe, near Sillans, the preliminary mining works for which are shown in Fig. 3.

About 50 French and Italian workmen are employed in mining the bauxite, which is then shipped to Toulon and thence to the Hebburn works. The special advantage of this arrangement is that cargoes of coal are already in great demand in the Mediterranean, and the colliers bring back the bauxite practically as ballast. It is, therefore, expected that the cost of production of alumina will be reduced below previous figures by the Hebburn works, because of the advantageous position and up-to-date plant employed.

The erection of the works, which occupy about one acre of a total ground area of close upon five acres, was begun on July 18, 1908, and its progress is being so vigorously pushed forward that in a very short time Tyneside alumina will be an accomplished fact.

The buildings consist of a furnace-house bay, 230 ft. long, together with two other bays of galvanized iron superstructures on a concrete foundation, devoted to the wet portion of the process.

A store is in process of erection, which will be capable of holding 2000 tons of bauxite and keeping it dry. The raw material is brought to this store by means of a full-gauge railway track, either from the North-Eastern Railway or from the closely adjacent River Tyne.

From the store the crude bauxite passes to the crushing house, where it is reduced to the fineness of flour. A motor-driven pneumatic separator plant both grinds and winnows the material at the rate of 40 tons per day; this plant was made by Messrs. Ernest Newell & Co., Ltd.

The ground material is then mixed with caustic soda, obtained from the neighboring works of the United Alkali Co., Ltd., and the mixture is lifted to a series of "kiers," or double-jacketed boilers, where the heat of steam in the outer jacket boils the liquid within. This arrangement is necessary to avoid dilution of the caustic soda.

After a number of hours' boiling it is blown into elevated tanks, and goes through an elaborate filtration process in a series of presses. The aluminate of soda which has been formed, being in a state of solution, passes through, while the suspended oxide of iron is rejected. A market for this by-product is now being developed, and this will constitute a further advance in the economical production of aluminium.

The aluminate of soda, after a second filtration, is brought up to such a state of purity that it is found in a subsequent stage that the amount of impurity in the hydrate of alumina is of the order of 0.001 per cent. After this filtration the aluminate of soda passes to a series of large tanks, each capable of treating upward of 45,000 gal. of liquid.

These tanks have large internal agitators electrically driven through two lines of shafting, seen in Fig. 5, and aluminium hydrate separates out and is drawn off to a third set of filters. The residue in the tanks, or "mother liquid," is the caustic soda, and so is the filtrate obtained from the third filtration.

The precipitate, however, is alumina in the form $Al_2O_3H_2O$. An electrically-driven air compressor blows air through this mass at a pressure of 8 lb. per square inch, and drives off the mechanically-contained water. The hydrate of alumina is calcined in the furnace house, a water-sealed gas producer being utilized to heat the furnaces, and the refined Al_2O_3 is then ready for transport to Wallsend or Dolgarrog.

It is, however, necessary to note the economical working of the plant as evidenced in the threatment of the caustic soda or mother liquid. This is passed back from the filters and large tanks to a series of evaporators for concentration, built by Messrs. Ernest Scott & Co., Ltd., of London. These consist of four large pans, 9 ft. in diameter, containing a series of tubes, through which the liquor passes and outside which steam plays.

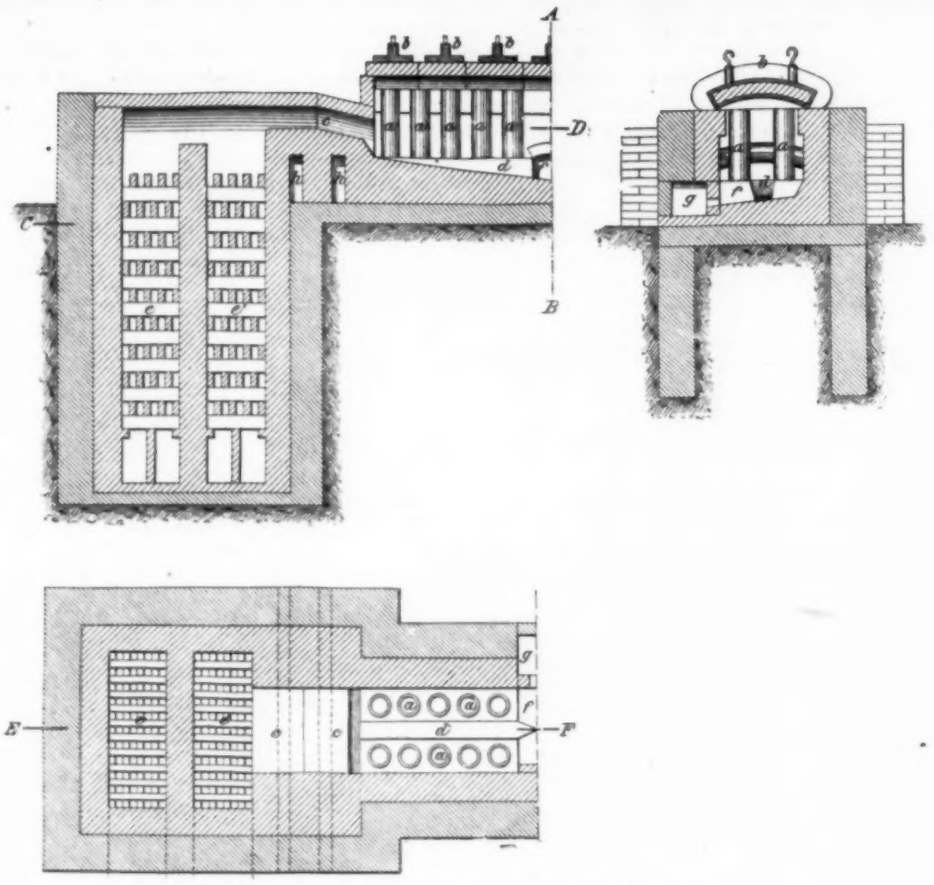
These are arranged so as to have a multiple effect. In the first pan exhaust steam at about 10-lb. pressure is used; the last of the series is subjected to a vacuum caused by a pump connected to a barometric condenser, and the vapor evolved from one pan boils the liquid in the pan next to it in such a way that it is possible to evaporate 2 lb. of water for every pound of steam originally used.

Moreover, the condensed water goes to feed the battery of boilers generating steam at 120 lb. per square inch for heating purposes and for generating electric power and lighting on the works. The heating is largely done by exhaust steam, the engines acting as a reducing valve.

Thus the Aluminium Corporation, Ltd., who hold five-sixths of the capital of the Bauxite Refining Co., Ltd., have caustic soda at their own doors; they have cheap coal, cheap electricity, cheap transit, and their own bauxite.

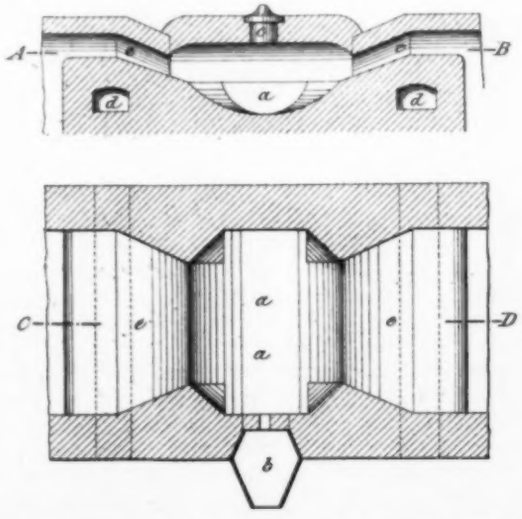
Kinlochleven Works.

As has been said before, the British Aluminium Co. is an old company. Its works at Foyers, with a capacity of 7500 hp,



FIGS. 1, 2, 3.—PRODUCER-GAS FURNACE FOR SMALL CASTINGS.

have been in operation since 1896. In spite of its name, the British Aluminium Co. also has works at Stangfjord, in Norway, and at Orsieres, in Switzerland, the total capacity of the various works being over 60,000 hp.



FIGS. 4 AND 5.—REVERBERATORY FURNACE FOR SMALL-SIZE METAL CASTINGS.

Their new British works are being erected at Kinlochleven in western Scotland. The hydraulic installation comprises nine large Pelton wheels, with an output of 3200 hp each, and two small turbines of 930 hp each.

The electric equipment comprises 20 main generators installed in all, each having an output of 1000 kw at a voltage of 250 to 275 volts. They are coupled in pairs to the water turbines. All the generators are of the direct-current multipolar type, with slot-wound armature, and are shunt wound.

As in order to comply with the exigencies of the work, they have to run continuously at full load day and night for months at a time, it is necessary that all adjustments, renewal of brushes, and necessary cleaning and lubrication should be possible while the machines are running.

Each generator has a normal full-load output of 1000 kw when running at its normal speed of 300 r.p.m., but it is also capable of an overload output of 1100 kw for one hour, and can be altered to give any voltage, when self-excited, between 200 and 275 volts with any load from 0 to 1000 amp by adjusting the speed alone. The generators are designed to run continuously, when necessary, at the highest speed required, viz., 330 r.p.m.

The main switchboards are very simple in construction and have been equipped by the British Aluminium Co. themselves. Their most interesting feature is the extensive employment of aluminium in their manufacture. This metal has also been used for the busbars on the lighting and power and traction boards.

The production of aluminium at the permanent Kinlochleven works will be commenced early in 1909. A temporary factory at Kinlochleven has been in operation for the last year.

The Use of Producer Gas in Chemical and Metallurgical Industries.

BY DR. OSKAR NAGEL.

While in Europe producer gas is widely employed in the chemical and metallurgical industries, in most of the American factories direct firing is still in use, although the advantages offered by producer gas are indisputable. The slow progress in the change from direct firing to gas firing in this country is possibly due to the fact that American manufacturers are not yet sufficiently familiar with the construction of producer-gas-fired furnaces suitable for their purposes. It may, therefore, be of interest to describe a few types of such furnaces which have been used successfully abroad for a good many years.

For small steel castings the furnace shown in Figs. 1 to 3 has proven an economical success. Fig. 1 is a vertical longitudinal section, Fig. 3 a vertical cross-section along line *A B* of Fig. 1, and Fig. 2 a horizontal section along lines *C D* of Fig. 1. These furnaces contain 20 crucibles and are built under ground up to the sole of the hearth, so as to enable the operator to easily lift the arch covers *b b* and to get hold of the crucibles *a a* by means of suitable tongues. *e* is the air-regenerator, *e'* the gas regenerator. The steel runs off through *d*, is collected at *f* and discharged at *g*. *c* is the flue, *h h* the cooling channels, which are connected with the stack.

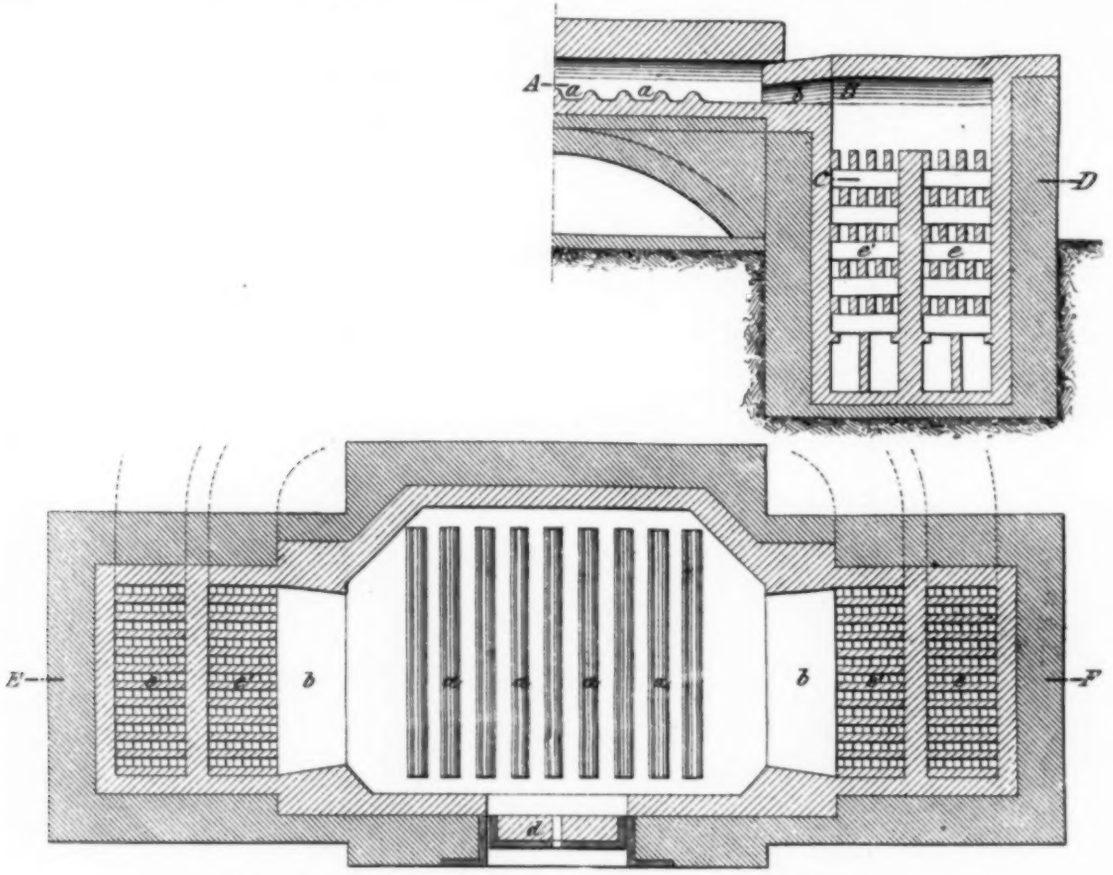
The life of the crucibles is as long as with direct firing; with

cast steel the operation takes about four hours and the hearth is to be renewed after every 52 operations.

A reverberatory furnace with regenerative gas firing for the manufacture of small-sized metal castings is shown in Fig. 4

This furnace is provided with a very low arch so as to keep the heat nearer the large area of the hearth. It is, of course, necessary to build these arches of sufficient strength.

By using producer gas in this furnace, the formation of



FIGS. 6 AND 7.—REGENERATIVE GAS FURNACE FOR HEATING COPPER PLATES.

(vertical section along *C D*) and Fig. 5 (horizontal section along *A B*). *a* is the "crucible," made of best fire clay; *b* is the charging and discharging opening; *e e* are the flues; *d d* are the cooling channels, and *c* is an opening (which can be closed) for charging during the melting operation. The pieces

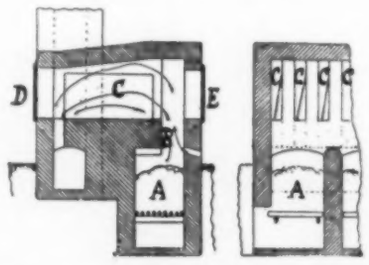


FIG. 8.—FURNACE FOR METAL SHEETS.

of iron or metal can be somewhat preheated in the channels *d d*, which always get dark red at a welding heat. In shipyards these furnaces are very convenient for casting screws, etc.

A regenerative gas furnace for the heat treatment of copper is shown in sections in Figs. 6 and 7. The hearth is provided with corrugations *a a* for enabling the operator to conveniently get hold of the sheet metal. *b* is the flue, *e* the air regenerator, *e'* the gas regenerator, and *d* the working door, which is provided with a counterweight.

A copper plate of about 90 lb. gets red hot in 7 or 8 minutes and in 12 hours 3 to 3½ tons of sheet metal are rolled; the coal consumption is about 1½ tons.

oxide is much less than with direct firing. This means a higher economy, since the yield of metal is increased and the time of treatment is reduced as a result of the diminution of the quantity of oxide formed, which is a non-conductor of heat.

A furnace for heating sheet metal is shown in Fig. 8. It consists of the producer *A*, the combustion chamber *B*, where gas and air are mixed; the chambers *C*, which are separated by vertical walls and contain the charge, and the charging doors *D* and *E*. All chambers communicate at one end with the combustion space, and at the other end with the flue.

Fig. 9 shows a crucible furnace for 36 crucibles, constructed by Dawson, Robinson & Pope (Brightside Steel Works, in Sheffield). It is said to work very satisfactorily. (See p. 40.)

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

Impact Tests of Iron and Steel.

Since the paper by Seaton and Jude before the Institution of Mechanical Engineers the feelings of metallurgists upon impact testing have undergone a change. In the first instance, their views as to the efficiency of the test were enthusiastically received; but in course of time a school led by Mr. Harbord began to express dissatisfaction and doubt as to the general reliability of the method. This dissent has culminated in a discussion before the Institution of Mechanical Engineers upon two papers concerning this subject, the first by Dr. T. E. Stan-

TON and Mr. L. BAIRSTOW dealing with "The Resistance of Materials to Impact," and the second by Mr. F. W. HARBORD treating of "Different Methods of Impact Test on Notched Bars."

Dr. Stanton, in introducing the first paper, said that in ordinary machine practice the stresses induced in moving parts were in general due to a combination of shock and gradually applied load. He and his fellow-author had already investigated the effects of reversals of direct stress, and it was thought that the determination of the effects on the same materials to sudden shock would be of value to the designer. Such a research was urgently called for since the proof resilience of a material—the *maximum* work which could be stored up per unit volume without permanently deforming it, as calculated from statical experiments—was quite unreliable as an index of "useful toughness."

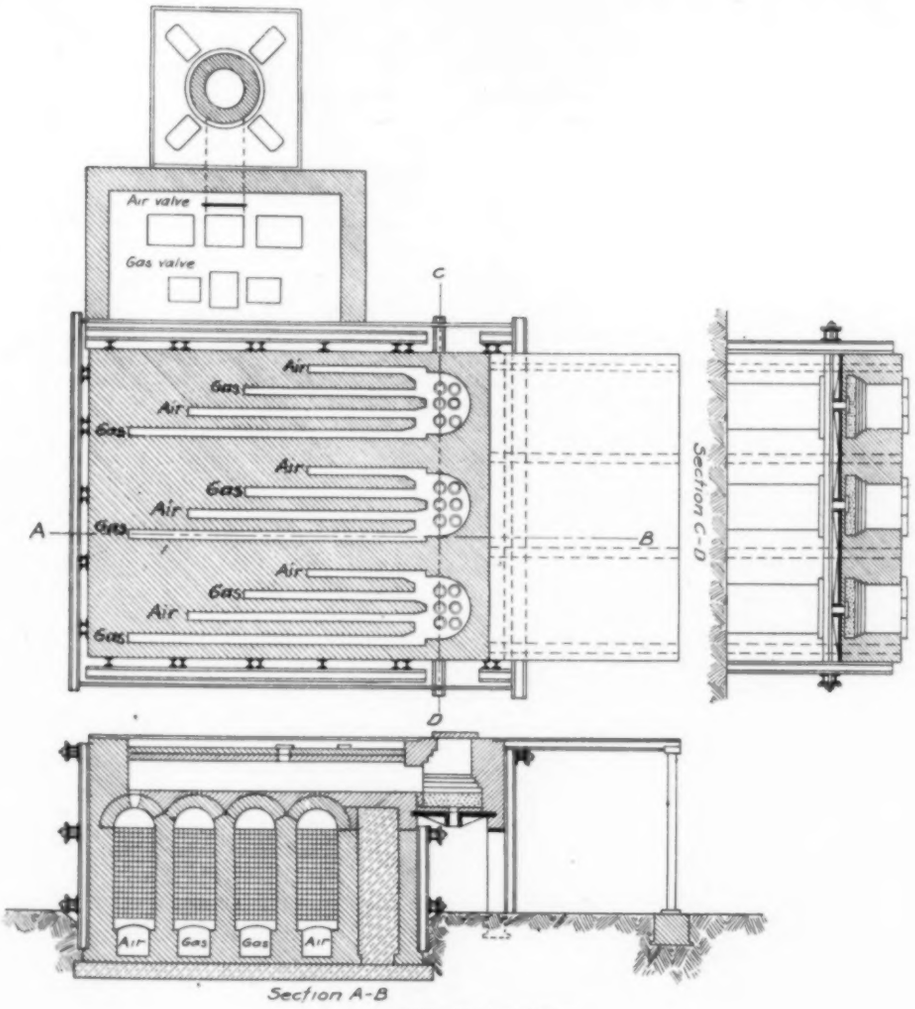


FIG. 9.—CRUCIBLE FURNACE.

As in the research on alternating stresses, the machines were designed for endurance tests up to one million shocks or more. These machines lent themselves equally well to the fracture of specimens under comparatively few blows; and the authors were led to the comparison of the result of impact tests, which consisted of a large number of small blows, with those consisting of a small number of heavier blows or even of a single blow to destruction.

An impact test may be made for one of two objects: (1) to ascertain if the material is brittle, or (2) to determine the resistance to shock under working conditions of the material relative to the resistance of other well-known materials. The first object primarily concerns the steel maker, who wishes to avoid supplying dangerous material; and the second concerns the engineer or designer. The detection of brittleness is obviously best accomplished by a single-blow test, and the proper means of determining resistance under working conditions appears to be a "shock-fatigue" test by a large number of small blows. Full descriptions of the machines employed were given, as well as particulars of the materials tested, which included Swedish charcoal iron, commercial and Swedish Bessemer steels, best English wrought iron, and boiler plates. The authors found that there is no source of weakness brought out by single-blow impact tests on plain or notched specimens which is not revealed by a careful static test.

The general conclusions are that for the detection of two important faults, brittleness and low elastic resistance, two distinct tests were necessary according as weakness in plastic resistance or inelastic resistance is to be revealed. Conclusive evidence was shown that materials which were strong under alternating stresses were generally strong under those shocks likely to be put upon them in ordinary machine practice, and not weaker as seems to be commonly supposed. The authors were unable to agree with Messrs. Seaton and Jude that the common interpretation of resilience had failed in its practical application; but, on the contrary, believe it to be the best guide for the designer in the use of normal materials of which the real elastic limits are known.

The experiments further showed that steel is a much more homogeneous material than it was recently suspected to be.

The changes in microstructure due to impact and to fatigue are dealt with and illustrated by photographs.

* * *

Mr. Harbord said that the experiments recorded in his paper were undertaken to compare the results obtained by different methods of impact testing and also to see whether such tests detected any irregularity in steel not revealed by ordinary tensile tests, and to what extent they were in agreement with the latter.

All steels used by engineers for structural and railway work were represented, and tensile tests of all the steels and hardness tests by the Brinell method were included. Five different methods of impact testing were employed, viz., those of Seaton, and Jude, Fremont, Izod, Brinell, and Kirkaldy; and over 40 different steels were experimented with.

Duplicate tests of the same material by each method for untreated steels showed that variation for the softest steels was greatest in the Kirkaldy horizontal method. With the second hardest steel Izod gave much the greatest variation, and both the Kirkaldy methods much the least. With the highest carbon steels Seaton and Jude, Fremond, and Izod all give most irregular results, and the Kirkaldy methods—both horizontal and vertical—alone give any approach to regularity. In the case of overheated soft steels (0.26 per cent carbon) this superiority is maintained; but with high-carbon steels and restored steels the Izod method appears to furnish the most uniformly consistent results. The author considers that the irregularity disclosed by the different methods of impact testing is not due to lack of uniformity in the material, but largely, at all events, results from the defects of the method of testing; and it is a serious question how far methods showing such variations should be relied on by engineers to differentiate between the physical properties of different materials.

The Arnold alternating tests show very little variation between the duplicate tests, although, like the tensile tests, they show that the overheated bars are more ductile than the restored.

With the exceptions of the steels below 0.2 per cent of carbon, all the commercial steels would be condemned by the Fremont method, as they all break below 100 foot-pounds. Not only were the tensile tests of these steels satisfactory, but they were good average samples of commercial steels from first-class firms. If we have to accept these impact tests as true indications of the quality of the material, we not only have to accept results in entire disagreement with the tensile tests, but entirely at variance with general experience.

Sir Robert Hadfield said that many of the troubles of the steel maker might have been reduced had the knowledge given by the investigation of impact tests been available at an earlier date. In the light given by Dr. Stanton's researches, the failures which had occurred in service were not surprising. It would appear that if impact testing were properly carried out the necessity for tensile tests would be largely reduced, and he agreed with the statement that impact testing by the single-blow method was likely to afford all the information which the steel maker and engineer required for the selection of the material best suited for endurance of shock. At the same time he did not suggest the abandonment of tensile tests. A branch of research which might yield valuable results was the study of steels at high temperatures, and he was himself carrying out tests in that field at Sheffield, which he hoped might lead to some useful results. Mr. A. Jude suggested that Mr. Harbord's results were broadly identified with variations in structure and were not due to the methods employed. Mr. Michael Longridge agreed with Dr. Stanton's view of the value of impact tests. It seemed to him, however, that the repeated application of small blows rather than a single blow-test was more likely to realize the conditions of service and to give a reliable test. Mr. Bertram Blount, who had on exhibition in the hall a machine for impact testing, designed in conjunction with Captain Sankey, said he had carried out satisfactory tests with the machine, which consists essentially of a vertical rod, which is a guide for a falling weight, the specimen being held in a suitable clamp.

The Institute of Metals.

At the first general meeting of the Institute of Metals at Birmingham, which took place on Wednesday, Nov. 11, the president, Sir William White, explained the objects of the society. In the course of his remarks he dealt with the reasons which had led to the establishment of the institute, and described it as another step in the direction of inevitable specialization. Its founders were confident its existence would be justified by its work; it was intended to promote community of interest and information, and it was also intended to promote free communication between the metal trades and users of non-ferrous metals. As regarding the latter class, he ventured to assert that no less importance attached to the interchange of information between manufacturers. No one could doubt that frank conference and discussion, such as the institute would encourage, might lead to a reconsideration of many conclusions hitherto regarded as definite and final. At present many difficulties and failures which occurred in the use of metals arose from causes that remained obscure and demanded thorough investigation. He was sanguine enough to believe that the establishment of the institute would promote the growth of the scientific spirit and in the end would lead to better conditions, to freer and more cordial intercourse, to united effort for improvement on the part of makers and users, and to the universal conviction that all classes must be benefited by encouragement of research and the freest publication of results obtained which circumstances might permit. If they were to succeed in that endeavor, the proceedings of the institute must embrace contributions from and discussions between users and makers of non-ferrous metals and their alloys. The cordial collaboration of members of the institute whose interest in metals was chiefly of a scientific character was one of the most important guarantees of their success. The range and variety of possible researches into the properties of non-ferrous metals and their alloys are so great that there is scope for all classes of investigators.

The Castner-Kellner Alkali Co.

The position of the Castner-Kellner Alkali Co. (Ltd.) remains eminently satisfactory. The net profit for the year ended Sept. 30, after the usual expenditure in keeping up works, plant and machinery to the highest state of efficiency, is £115,528 3 9, which with £14,420 9 4 from 1907 made £129,948 13 1. Interest required £9,443 2 7, and interim dividend at the rate of 10 per cent for the six months to March 31, £22,500, and the available balance is £98,005 10 6. The directors are putting £30,000 to depreciation reserve, writing £5,000 off suspense account and £1,386 off plant accounts, placing £12,500 to general reserve, appropriating £33,750 in payment of a final dividend of 1s. 6d. per share (making 12½ per cent for the year), and leaving £15,369 10 6 to be carried forward.

The Thermit Process.

Mr. R. Stütz, managing director of Thermit (Limited), London, delivered a lecture before the members of the Sheffield Society of Engineers and Metallurgists on Monday, Nov. 16, on "The Aluminothermic Process." He described the composition of this heat producer. The principle underlying the process is the affinity which aluminium has for oxygen. In a mixture of aluminium and iron oxide, for instance, the aluminium will combine with the oxygen in the oxide, and set free the pure liquid iron at a temperature of about 5400° Fahr. Dealing with thermit welding, he showed that iron in a very fluid state is produced and runs into the open spaces left for it in the mould. The main advantages of thermit process for the welding of tram rails were the obviating of loose joints and knocking noises. There was also an enormous saving in

the repair and maintenance of the permanent way, as well as a lengthening of the life of the rail. Taking the life of a rail as 12 years, the annual cost of repairs and maintenance, after the first five years, might on an average be taken at £150 per mile, or if welded joints were used, a saving of £75 per mile per annum for seven years. At the present time most of the rails which required renewing were only about two-thirds worn out, except at the joints, owing to the impossibility of keeping the rail ends tight and level, as the result of the poor support given by the customary method of joining. The initial cost of the joints, based on 60-ft. rails, was only about £30 to £40 per mile in excess of ordinary joints. The welded joint also secured perfect and permanent electric conductivity without the use of copper bonds, which generally after a few years' service became less efficient. This method of welding tram lines had now been used in about 50 different towns in this country alone.

Metallic-Filament Lamps.

The impetus to the lighting industry natural at this time of year has served to emphasize the tendency toward flame arcs and metallic-filament lamps in electric lighting. Figures of comparative burning of osram and tantalum incandescents are available in a case where 168 of the former and 848 of the latter are installed, making a total of 1016. At the end of 1200 hours, 84 of the original osram and 285 of the original tantalum lamps were still in use, i. e., 50 per cent of the original osram lamps and 33 1/3 per cent of the original tantalum lamps were still in working order. The former lamps cost 2s. 11½d. each and the latter 1s. 10¼d. each, so that the difference in the actual cost of renewals when the average life is considered is but slight, while the consumption of the tantalum lamp is 40 watts and of the osram lamp 28 watts for equivalent candle-power.

The Weighing of Ore Cargoes.

The British Vice-Consul at Rio Marino reports that the Italian government has introduced a practical method of weighing cargoes of iron ore. The ore from the mines being transported exclusively by water, it has been possible to lay down rules for loading vessels by the "Provini" test-tube areometer system under government inspection. This system consists of a pair of brass tubes affixed to either side of the vessel at one-third of her length between the deck and the hold. A graduated scale of measurements in tons and hundredweights is attached to a floater at the water line. Upon operations commencing, the lids of these tubes are removed and the scale rises automatically, marking first the stores, etc., which form no part of the cargo. As the latter is stowed, the scale rises. The weight loaded can thus instantly be ascertained; for example, fore part of ship, 127 tons 4 cwt., and aft, 136 tons 6 cwt., equals 263 tons 10 cwt. Deduct 4 tons 6 cwt. stores, the net weight put on board will be 259 tons 4 cwt.

SYNOPSIS OF PERIODICAL LITERATURE.

Iron and Steel.

Rusting of Iron.—The Materialsprüfungsamt of Gross Lichterfelde has recently issued a most exhaustive treatise on the influence of water and aqueous solutions on the rusting of iron. The work comprises some 104 pages of text and 148 illustrations, and was carried out under the direction of Prof. E. Heyn and O. Bauer. A brief abstract appears in *Stahl und Eisen*, Oct. 28. The rôle played by CO_2 furnishes the foundation for a series of experiments the results of which are summated as follows: 1. Iron will rust under conditions in which CO_2 is absolutely absent. 2. Air containing 15 per cent CO_2 under the same conditions is only twice as active as air absolutely free from CO_2. It is not likely or possible that the small amount present in the atmosphere exerts any action on the process of rusting. 3. The degree of attack is dependent on the manner of introducing oxygen (bubbling of air, exposure to diffusing air, etc.). The introduction of oxygen by bubbling air through the solution is about twice as active in promoting rust as the simple contact of the surface of the liquid with the air. 4. The rusting is dependent on the partial pressure of the oxygen in the atmosphere above the liquid immersing the sample. In an atmosphere of pure oxygen the attack is three times as strong as in ordinary air. Pure CO_2 causes no peculiar rusting. It acts as any acid by dissolving with the evolution of hydrogen. True rust only appears on the introduction of oxygen. Free oxygen is necessary for rusting, the presence of the oxygen combining with hydrogen as water playing no part in the action. Iron is an extraordinary sensitive reagent for the determination of oxygen dissolved in water. It is not, however, available for quantitative determination because the loss of weight of the iron is partly due to oxide in each of the two states, the proportion of ferrous and ferric not being constant. Rusting may be prevented by removal of oxygen from water. Evacuation and boiling are not techincally possible in most cases. Even when removed a coating of oil will not prevent reabsorption of air. With this knowledge of corrosion it may be said that the velocity of rusting is proportional to the distance of the metal from the surface of the liquid in contact with the atmosphere; to the area of this surface of contact; to the rate at which oxygen is bubbled through the solution; to the partial pressure of the oxygen in the atmosphere above the liquid; to the rate at which the fluid in which the iron is placed is renewed; to the proportion between the surface of the iron and the volume of the liquid it is in; a mathematical discussion is given of these ratios. The action of hydrogen peroxide in various concentrations allowed of no particular conclusions being drawn. In regard to the attack of the metal of gas holders where the same came in contact with the water in the well, it was believed that the illuminating gas retarded corrosion.

In general, it was proven that iron rusts less and the other metals more when placed in contact with a metal lower in the e.m.f. series than the iron when placed in a solution which ordinarily rusts iron. The opposite is true when in contact with a metal above itself in the series. A sample of iron in contact with copper rusted 25 per cent more in the tap water of Charlottenburg, and 47 per cent more in artificial sea water, than when placed in these two solutions alone. Contact with nickel increased the attack on the iron 14 to 19 per cent. Cast iron in contact with wrought iron protects the wrought iron at its own expense. The wrought iron showed 28 per cent less corrosion in a solution through which air was bubbled, and 50 per cent less in a solution in contact with quiet air. In general, it was found that iron in contact with identical metal mechanically treated in various ways showed a difference in potential between the various samples. When overheated and non-overheated metal are placed in contact in water, the non-overheated metal is more strongly rusted than when placed therein alone.

The third part of the investigation is concerned with the rate of attack on various kinds of irons, details of analysis, etc., being given in the original. In the case of cast irons no conclusions could be drawn on the effect of the various ingredients in the metal. A series of experiments was also carried out on the attack of various liquids on the iron at room temperature. The data is essentially given in form of curves. Chromic acid and potassium iodate seem to have a critical concentration above which there is no attack, magnesium nitrate, sodium nitrate and sodium sulphate showing the same phenomenon at considerably higher concentrations. It was not proven that sodium carbonate and other alkaline solutions protected from rust, or that sodium and potassium chloride or sulphates accelerated corrosion, as is commonly believed. Chromic acid and potassium chromate are the best protections against rusting. The final portion of the paper is concerned with the

measurements of the potential of iron against various fluids as measured with the normal electrode.

Cupolas.—Bernhard Osann gives some dimensions of foundry cupolas in *Stahl und Eisen* for Oct. 7. From a general consideration of the best working foreign cupolas they are found to average a section at tuyeres of 1100 sq. cm. (175 sq. in.) per ton of output per hour. American practice is 1650 sq. cm (260 sq. in.). The section of the cupola should markedly contract toward the tuyere section. A formula for the calculation of the pressure of the blast is $H = 50\sqrt{Q}$, where H is the pressure of the blast in centimeters of water and Q the volume of air supplied per second. Q should be proportioned to give the largest possible proportion of CO_2 in the gas. The total area of the tuyeres should be one-fourth to one-fifth of the area of the tuyere section. Under these conditions the coke consumption will vary between 9 and 11 per cent of the weight of the iron melted. The limestone addition varies greatly in the different plants, from 27 to 40 per cent of the coke charged.

Iron-Silicon-Carbon Alloys.—In *Zeitschrift für anæganische Chemie*, W. Gonterman reviews the iron-silicon-carbon alloys. In regard to the binary systems which contribute to this equilibrium, an iron containing 0.07 per cent carbon showed consistently a halting point on cooling curve at 1411°, in addition to the usual ones at 852° and 770°. This is designated as a questionable transition point. In the system iron-carbon the well known compound Fe_3C is thought to fuse to two emmiscible liquids, one rich in iron and one rich in graphite. An elaborate discussion, with diagrams, supports this. On cooling the liquid mixture, cementite first crystallizes from each phase. On further cooling, cementite from the iron-rich melt crystallizes with graphite as an entectic. At 1100° (a temperature below the entectic) non-variant equilibrium between cementite, martensite and graphite occurs, owing to changes in stability between cementite and graphite. Below 1100° two sets of conditions are determined by the temperature: (1) absolutely stable system, the solubility of grahpite in iron decreases with fall in temperature and separates from the corresponding phase, martensite. (2) Unstable system—graphite formation is prevented and martensite suffers transformation into cementite and ferrite. This gives a satisfactory explanation of the formation of kish in alloys containing over 5 per cent carbon, this superficial graphite corresponding to crystallization of the upper graphite rich layer.

The ternary system was studied within the limits Fe — Fe_3C — Fe Si. A curve of monovariant equilibrium divides this region into two sections, the curve joining the binary entectic points Fe — C and Fe — Si. In the region between this curve and the curve joining the concentrations of the two compounds Fe_3C and Fe Si there occurs primary crystallization of "mixed crystals" (silicon-cementites) and secondary crystallization of a mixture of this variety of mixed cystals with another ternary variety. This latter variety of mixed crystals may be regarded as martensite containing silicon. Their crystallization surface lies above the region between the previously mentioned curve of monovariant equilibrium and the pure iron point. The curve joining the two points which give the saturation concentrations of binary mixed crystals in the respective systems Fe — C and Fe — Si shows the silicon and carbon contents of the saturated silicon-martensites. Melts, the concentrations of which lie between the curve of saturated silicon-martensite and the iron point, on cooling separate out unsaturated silicon-martensites. Melts whose concentration lie between the curve of saturated silicon-martensites and the first mentioned curve of monovariant equilibrium form primary crystals of saturated silicon-martensites, concluding the solidification by forming secondary crystals of saturated silicon-martensites and silicon-cementites. Analogy between the binary system iron-carbon and the ternary system iron-carbon-silicon can be discerned. It is particularly preserved in the polymorphic transformation. In the ternary system, as in the binary system, either a formation of graphite or a transformation of the primary mixed crystals to constituent metal and compound is marked by a continued fall in temperature.

Chromium and Manganese Alloys.—G. Hindrichs in the same journal also records an elaborate series of investigations on the chromium and manganese alloys, the results of which he summarizes in the following table:

	Gap in miscibility.		
Alloy.	Liquid phase.	Crystalline phase.	Compounds.
Sn-Cr	0-87% Cr	0- 95% Cr	None
Pb-Cr	10-75% Cr	0-100% Cr	"
Cu-Cr	2-98% Cr	0-100% Cr	"
Ag-Cr	0-92% Cr	0-100% Cr	"
Al-Cr	0-36% Cr	0- 85% Cr	$AlCr_2$ (?)
Al-Mn	14-42% Mn	0- 62% Mn	Al_2Mn (?), $AlMn_6$ (?)
Ag-Mn	2-87% Mn	0-100% Mn	None

Fusion diagrams are given in all the above cases.

Coke.

Analysis.—An investigation of the great discrepancy which existed between laboratory tests and actual practice in the coke output of bituminous coals was carried out by F. W. Hinrichsen and S. Taczak at the Königliche Materjalprüngsamt, Gross Lichterfelde. The following new method of proximate analysis was determined upon: Four to 5 grams of finely pulverized coal is placed in a Rose crucible of 40 cc to 50 cc capacity; diameter at bottom, 20 mm; height, 50 mm; top diameter, 50 mm. Hydrogen is introduced through the tube for 10 minutes, then it is heated for two minutes with moderate bottom flame, then for five minutes with bottom flame and two side flames, or the heating is continued until the yellow flame disappears, using the three burners. It is cooled in the current of hydrogen. Determinations made by this method usually show several per cent higher coke output than the older methods and agree very well with practice. In a set of comparative determinations made with the two "Muck" methods and this one, the results derived in practice were a shade lower than the experimental determination in hydrogen, and several per cent nearer than the "Muck" determinations.

Smelter Fumes.

Injury to Vegetation and Animal Life by Smelter Wastes.—This is the subject of an interesting contribution of Mr. J. K. Haywood in Bulletin 113, Bur. Chem., United States Department of Agriculture. This is a report of the work done in and around Anaconda, Mont., to determine the effect upon vegetation and animals of the several wastes from the reduction of ores as practiced in that locality. The wastes are classified as (1) sulphur dioxide, given off and allowed to escape in the atmosphere during the process of smelting; (2) the volatile arsenic given off in the smelter fumes; (3) flue dust from smelter stacks containing fine particles of copper, lead and zinc; (4) the leachings from tailings which are allowed to run into streams, the water being used later for irrigating purposes.

A report is also made of an experimental study of the effect upon vegetation by sulphur dioxide, and the resisting power of numerous plants to the injurious effect of this gas, together with methods of analysis used in the investigations. As a result of the investigations, the author concludes that: The forests around the smelter appear from actual chemical analysis to be injured for at least 10 miles north of the smelter; 6 miles south of the smelter and 13 miles west of the smelter. This injury to forests by sulphur dioxide undoubtedly extends to a distance of 15 to 20 miles north of the smelter, 8 miles south of the smelter and 15 miles west of the smelter, and perhaps even farther in certain localities, although not proved by chemical analysis. The junipers are very resistant to smelter fumes and are able to grow close to the smelter; the red firs are susceptible to the fumes and are badly damaged at distances of about 15 miles, or perhaps even farther; the lodgepole pines are intermediate between the other two species of trees, but show damage for at least 10 miles. Large quantities of arsenic are discharged from the smelter on the surrounding country, this poison being found in forage crops in large enough quantities to poison cattle. The waste from the reduction plant dis-

charged into the Deer Lodge River renders it unfit for irrigation purposes. The land irrigated by the Deer Lodge River, containing the waste from the reduction plant, is greatly injured by the copper present in the irrigation water. The soils irrigated by the Deer Lodge River, which were studied by the writer, do not contain enough alkali salts to be injurious to ordinary farm crops.

This Bulletin recalls the work which appeared in the *Journal* of the American Chemical Society in June of this year. The first paper on "Arsenic in Vegetation Exposed to Smelter Smoke," by R. E. Swain and W. D. Harkins, was concerned with the vegetation of the Deer Lodge Valley, near Anaconda, Mont. Many samples of grass and hay were examined, the largest amount of arsenic as As_2O_3 found was 1551 parts per million. The authors believe that the evidence produced warrants the conclusion that the arsenic is not absorbed from the soil, but is deposited from the smelter fumes.

The second paper, by W. D. Harkins and R. E. Swain, on the "Chronic Arsenical Poisoning of Herbivorous Animals," describes the poisoning of animals by arsenic in the vicinity of Anaconda, Mont. Autopsies of a large number of animals were made and many samples analyzed showing arsenic in considerable quantities in the body tissues. A number of grasses and hays were examined and large amounts of arsenic found, in some cases as much as 155 parts of As 203 per million.

Thorium.

Chloride.—Dr. Werner von Bolton contributes to the Nov. 20 number of *Zeitschrift fur Electrochemie* an interesting article on thorium. He prepares thorium chloride by heating thorium oxide to bright redness in a glass tube and passes over it carbon tetrachloride, the reaction being $ThO_2 + CCl_4 = ThCl_4 + CO_2$. By placing this chloride in an iron crucible in alternate layers with sodium, covering with calcium chloride and heating, he received within 4 per cent of the theoretical output of the metal, calculated on the oxide used. The metal obtained consisted of a felt-like mass of crystals. By packing these crystals in a copper tube and passing the whole through rolls and subsequently dissolving off the copper envelope in nitric acid, a wire of pure thorium could be made. This wire could be rolled out into a ribbon if desired. Heated to 1450° in a vacuum the wire could be fused to a homogeneous whole. The color, hardness and ductility of the metal correspond to those properties of platinum. The density of the powder was found to be 11.32; of the rolled and heated wire, 12.16. Boiling caustic potash or nitric acid do not attack the metal; sulphuric acid slightly; hydrochloric acid, easily. A compound of thorium which does not have the properties of the ordinary thorium compound has been called by the author muriaticum-thorium. It is made by dissolving pulverized thorium in 5 per cent hydrochloric acid. After filtering from the part of the metal which does not go into solution, it can be precipitated by heating. It is soluble in water, dilute hydrochloric acid, not in concentrated hydrochloric acid. It does not precipitate silver from silver solutions. Its formula has been determined as $(ThO_2)_{10}.(HCl)_4$. A complete table of comparative qualitative properties of normal chloride and muriaticum is given in the original. No difference was found in the radio-active properties of the two compounds.

Units and Constants.

The Committee on Definitions and Units, representing a number of German technical and scientific societies (among them the German Bunsen Society), has recently published a new set of definitions and units in reference to electrical and mechanical branches. Definitions are given of potential, potential differences, electric tension, electromotive force, etc. The reciprocal of the resistance is called the conductance; the unit is called the Siemens, designated by S (that is, what we call mhos in this country). This reciprocal of resistivity or specific resistance is called conductivity or specific conductance.

The following values of the mechanical equivalents of heat are given:

The mechanical equivalent of the 15° gram calorie is 4.189×10^7 ergs, or 4.189 joules.

The mechanical equivalent of the average calorie (0 to 100°) is the same as that of the 15° calorie.

The numerical value of the constant R of the gas law $pv = RT$ is $R = 0.8316 \times 10^8$ when pv or RT is given in ergs, or $R = 8.316$ when pv is given in joules, or $R = 1.985$ when pv is given in gram calories.

The constant of Joule's law is 0.2387 (i. e., 1 joule or watt-second = 0.2387 gram calorie).

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Treatment of Aluminium Silicate.—A batch of interesting patents on the treatment of aluminium silicate in the electric furnace have been granted to Mr. Frank J. Tone, superintendent of the Carborundum Co. Aluminium silicate is an ore of wide occurrence and is the basis of all true clays. Kaolin is mixed with carbon so as to reduce the silicon, but not the aluminium, i. e., about 222 parts of ore to 48 parts of carbon. Treatment in an electric arc furnace yields the reaction

$$Al_2O_3.2\,SiO_2 + 4\,C = Al_2O_3 + 2\,Si + 4\,CO.$$

The products are, therefore, alumina and silicon. The fused alumina tends to settle to the bottom of the furnace. (906,338, Dec. 8, 1908.)

The reduction of the silicon by the above reaction is facilitated by adding to the charge base metal or ore, such as iron or manganese, which alloys with the silicon and makes the reduction of the latter more complete. For instance, 222 parts of calcined kaolin may be mixed with 48 carbon and 56 iron. Then the reaction in the arc furnace is

$$Al_2O_3.2\,SiO_2 + 4\,C + Fe = Al_2O_3 + FeSi_2 + 4\,CO.$$

The iron silicide being heavier than the alumina has a tendency to settle to the bottom, from which it may be tapped at intervals during the run. It also agglomerates in nodules of greater or less size throughout the finished product. After the ingot has cooled, it is broken up and the silicide is separated from the alumina; for instance, first by hand separation and then by crushing and some mechanical method of concentration. By adding manganese or manganese ore in the proportions to form a silicide containing 45 to 50 per cent manganese, the alloy is very friable and on exposure to air tends to disintegrate into a fine powder. An iron silicide containing 35 per cent iron is of similar character. (906,172, Dec. 8, 1908.)

By using less carbon in the charge than corresponds to the above reactions, not all the silicon is reduced. For instance,

$$2\,(Al_2O_3.2\,SiO_2) + 6\,C = 2\,Al_2O_3 + SiO_2 + 6\,CO + 3\,Si.$$

In this case a mixture of 77 per cent alumina and 23 per cent silica is produced in form of a homogeneous material of great hardness and with valuable abrasive and refractory qualities. Of course, in this case iron may again be added to the charge, in order to obtain the silicon in form of ferrosilicon. By further varying the amount of carbon in the charge, the percentage composition of the alumina-silica mixture may be still further varied. (906,173, Dec. 8, 1908.)

The fused alumina-silica material has a hardness equal to that of many grades of corundum and is very tough. It is, therefore, valuable as an abrasive. It may also be used as a refractory. When it is tapped from the furnace, it may be cast into molds. Its hardness and toughness may be varied by varying the ratio of silica and alumina, and these valuable qualities are possessed by the material, while its silica content varies between 5 and 35 per cent. (906,339, Dec. 8, 1908.)

Tantalum.—To make a homogeneous body of tantalum metal, Dr. W. von Bolton, of Siemens & Halske Co., presses tan-

talum powder together in form of a bar and sends an electric current through this bar, using metallic tantalum electrodes. The powder is thereby fused together. The process is carried out in a vacuum as complete as possible. The fused body thus obtained is quite homogenous and has such a high degree of ductility that it can be rolled into very fine sheets and drawn into the finest of wires. (904,831, Nov. 24, 1908.)

Calcium Carbide.—Mr. E. F. Price, general manager of the Union Carbide Co., has patented a calcium carbide furnace, shown in Fig. 1, the special feature being the method of pre-

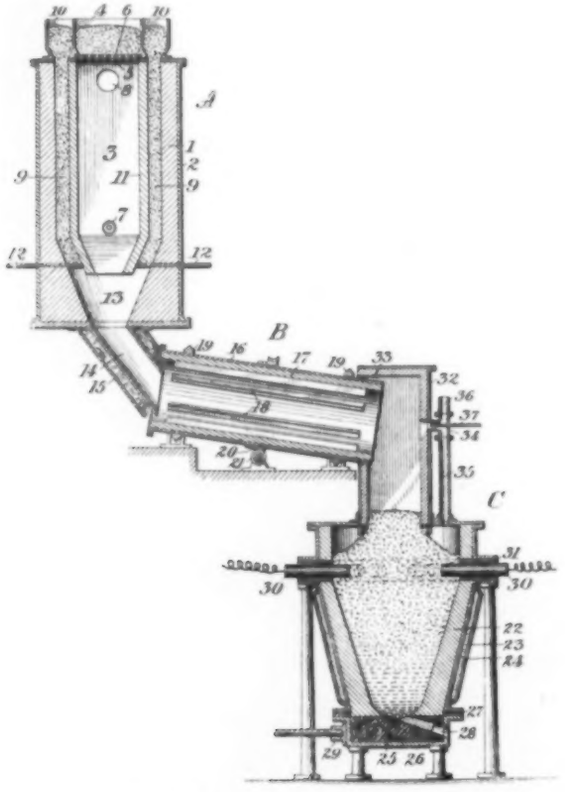


FIG. 1.—CALCIUM CARBIDE FURNACE.

heating and feeding the charge. The preheating apparatus *A* is a rectangular tower 1 of firebrick, enclosing the lime chamber 3. The lime and carbon are charged separately. The lime falls from the hopper 4 and through the inner chamber 3 in form of a shower and is thereby heated by the hot products of combustion rising upward from the burners 7 and escaping through 8. The carbon is fed from the hopper 10 and moves downward through the passages 9 in the wall of the tower. The preheated materials pass into the revolving cylinder *B* which acts as mixer, and then into the electric furnace *C*, in which the mass acts as resistor, the bottom 25 of solid carbon acting as one electrode and carbon rods 30, arranged radially at the top, as the other electrodes. Molten calcium carbide collects on the bottom and is tapped through 28. A burner 34 opens into the chamber 32 opposite the end of the mixer and is fed with waste carbon monoxide from the furnace through the pipe 35, while air is supplied by pipe 37. In this way a high temperature is maintained in the mixer. (904,991, Nov. 24, 1908.)

Metals and Alloys Free from Carbon.—A recent patent of F. M. Becket, like others of the same inventor noticed before in these columns, relates to the use of silicon as a reducing agent in electric furnaces for production of pure metals like chromium free from carbon. In the present case carborundum or carbon silicide is used as reducing agent, and the method of making ferrochrome is as follows: As the chromium in chromite exists as chromium sesquioxid, Cr_2O_3, and practically all the iron as ferrous oxide, FeO, the following reactions take place:

$$Cr_2O_3 + SiC = 2\,Cr + SiO_2 + CO.$$
$$3\,FeO + SiC = 3\,Fe + SiO_2 + CO.$$

A fair commercial grade of chromite contains 25 per cent Cr_2O_3 and 16 per cent FeO, and 100 lb. of this ore will, therefore, require, according to the above reactions, about 16.6 lb. of SiC for complete reduction of the chromium and iron. It is advantageous to use the silicide of carbon and chromite in a fairly fine state of subdivision, depending on the scale of the operation. The use of a basic flux, such as lime, is usually advantageous as tending to economy of operation. By mixture in practically theoretical proportions a high yield of chromium and iron is obtained. If it is important to get a very low silicon content in the alloy (less than 0.2 per cent), the chromite is used in slight excess. The process is carried out continuously in an electric furnace in which the current passes through a molten bath of a mixture of ore, silicide of carbon and flux, and from which part or all of the metal or slag may be withdrawn as desired, fresh portions of the mixture being added from time to time. Since the reaction between carbon silicide and the oxides is exothermic, a relatively small amount of electrical energy is required. The materials should be used in a finely subdivided state and well mixed.

Electrolytic Processes.

Bleaching Liquor.—A. Vogelsang patents details of construction of an electrolytic apparatus for producing hypochlorites or bleaching liquor from aqueous solutions of rock-salt. In his cell the liquid used as an electrolyte is cooled down

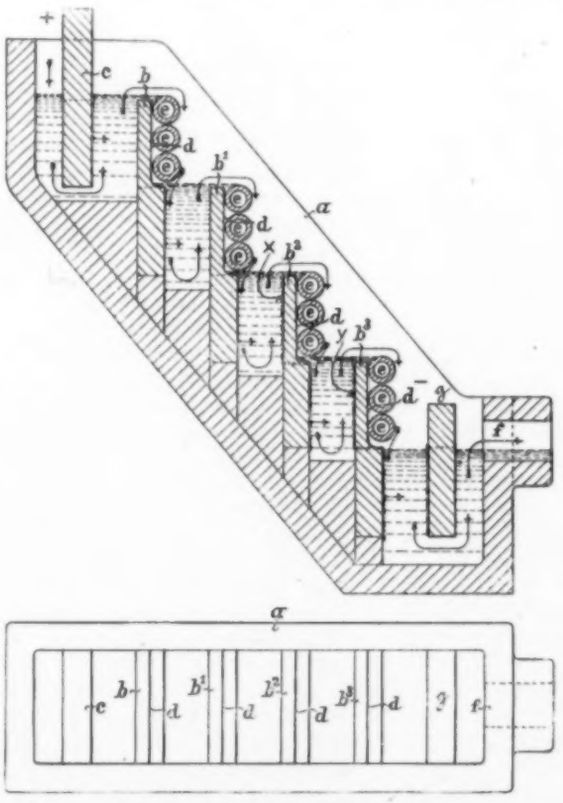


FIG. 2.—BLEACHING LIQUOR CELL.

during its overflow from one compartment to the next one either by its contact with the atmospheric air or by suitable cooling tubes or by both, in such a manner as to obtain a thorough or intimate mixing of the electrolyte within the compartments and obviating an increase of the temperature in the same. For this purpose the electrodes, arranged in the form of partitions, are provided in step-like formation within a slanting vessel. One of the electrodes forming a wall of one compart-

ment is continued or projected above the bottom of the vessel in such a manner that its projecting part forms the wall of the compartment next above. In this manner, a non-electrolytically acting surface is formed on one side of the partition over which the electrolyte will flow down in a thin layer on its passage from one compartment to the next one and will thereby be cooled. The cooled electrolyte falls down within the compartment on one partition of the electrode and rises on the other partition, so that a constant circulation within the compartment is secured and a heating of the electrolyte is obviated. The electric current selects that path which offers the least resistance and, therefore, very little current will pass through the thin part of overflowing solution, as the current passes chiefly through the electrode from one side to the other. In Fig. 2 b, b^1, b^2 are the electrodes of graphite or platinum, acting as bipolar electrodes. Thus, the lower part of the right-hand surface of b acts as anode, and the upper part of left-hand surface of b^1 as cathode in the same compartment. The upper parts of the right-hand surfaces of b, b^1, b^2, all being marked d, are non-conducting surfaces of glass, slate, etc., e are cooling pipes, c is the anode at one end and g the cathode at the other end. The path of the solution through the cell is indicated by arrows. (906,669, Dec. 15, 1908.)

Ornamental or Protective Coatings for Platings.—E. C. Broadwell recommends for ornamental or protective coatings the use of a readily soluble sulphonate, preferably the naphthalene disulphonate, as electrolyte. For plating with zinc he uses a solution of zinc sulphate with zinc naphthalene disulphonate. For brightening the deposits, a small percentage of aluminium sulphate is added to the latter solution. (905,837, Dec. 8, 1908.)

Zinc Plating.—To plate iron and other metallic surfaces with a coating of zinc C. Bianco recommends an electrolyte made up of 50 to 150 parts of zinc, 2 to 15 iron, 0.5 to 10 aluminium, 0.5 to 10 sodium, 80 to 280 sulphuric acid, 0.5 to 8 acetic acid and 886.5 to 527 water. A soluble zinc anode is used. (905,785, Dec. 1, 1908.)

Discharges Through Gases.

Electrodes for Arc Discharges.—A. G. Davis (General Electric Co.) recommends the use of magnetite (Fe_3O_4) electrodes for arc discharges through gases to produce certain chemical reactions in the gases. The electrodes may be made by pulverizing natural magnetite, mixing with a suitable binder, such as water glass and molding. Electrodes of this kind give a long, brilliant arc; when used for the fixation of atmospheric nitrogen, they are unattacked by the nitric acid and appear to have a catalytic action. (905,666, Dec. 1, 1908.)

Striking Arcs.—When gases are treated by long electric arcs revolving under the influence of a magnetic field (as in the Birkeland-Eyde process) a difficulty is found in striking the arc when the electrodes are far apart. A. J. Petersson uses an auxiliary arc from another circuit, which may be of low intensity and is moved in the well-known way by electromagnetic means so as to get near the high-intensity arc to be struck. The latter is thereby lighted without any necessity of bringing the electrodes near together and without a detrimental effect on the power factor of the circuit. (905,572, Dec. 1, 1908.)

Ozone.—Jan Steynis endeavors to maintain during the ozonizing process the lowest temperature practicable, at which temperature the chemical equilibrium gives the largest percentage of ozone. The cooling effect is obtained by means of evaporation of a liquefied gas. The electrodes between which the silent discharge takes place are flat in form and hollow, and of a sinuous tube form, and in the same the liquefied gas is allowed to expand so as to produce the cooling effect. Glass plates between the electrodes act as dielectrics. The apparatus is claimed to generate 80 grams of ozone per kw-hour, with a concentration of 3.4 grams of ozone per cubic meter of air treated, and the inventor has been able to use a current strength of 0.5 ampere with electrodes having 1.4 square meters of surface without undue heating of the apparatus. (906,081 and 906,468, Dec. 8, 1908.)

A recent patent of Dr. Henry Noel Potter (assigned to Cooper Hewitt Electric Co.) refers to "the method of producing and utilizing ozone, which consists in passing an electric current between electrodes inside a container previous to ozonizing radiation, preventing a dissipation of the ozone and transmitting the ozone generated to a selected point." As described in our Vol. V, p. 390, a discharge is produced in a tube of silica (which is pervious to ultraviolet rays) between electrodes of mercury or between an electrode of mercury and one of iron, ozone is produced in large quantities in the air around the silica tube. The latter is enclosed again within another tube of ordinary glass (which is impervious to ultraviolet rays). If air is then passed from one end to the other end through the space between the outer and inner tubes, it is ozonized and the ozone is collected. The air is forced to pass between the two tubes in a zigzag path.

Fixation of Atmospheric Nitrogen.—G. Birkeland, who has done so much in the past to bring this problem to a commercial solution, has recently modified his revolving arc method so as to get a longer arc. The electrodes are placed at a considerable distance from each other. The method is now more similar to that of the Badische Co., while the deviation of the arc by means of a magnetic field is the same as in his former construction. The new furnace is shown in Fig. 1. The furnace B, composed of an iron casing with removable heads and lined on the inside with fireproof material, has a cylindrical shape. The electrodes C project through openings in the heads into the furnace and air is blown into the same through the openings D at one end and the products obtained are taken out through openings E at the other end. The field is created by means of a coil A surrounding the furnace casing, supplied by either direct or alternating current. The arc may be started in any convenient way; for instance, by moving for a moment one electrode near to the other; when again separated the flame will take a form as indicated in the picture and violently rotate within the furnace, thereby also causing the air to rotate, so that a very intimate contact between the air and the flame and a thorough mixing of the products formed with the surplus of air will take place. (906,682, Dec. 15, 1908.)

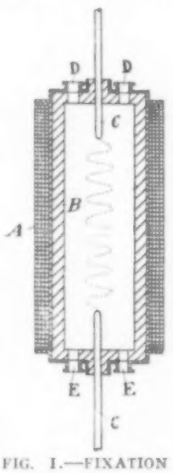


FIG. 1.—FIXATION OF ATMOSPHERIC NITROGEN.

Batteries.

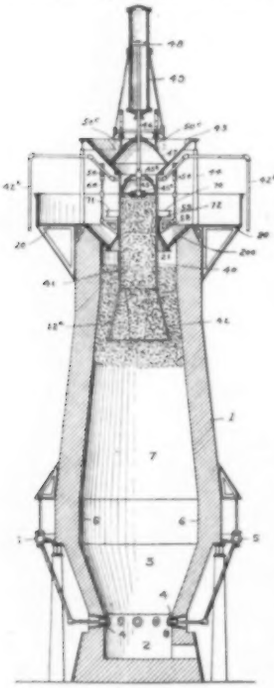
Negative Pole Plate of Lead Cell.—It has been known in the past that the shrinkage of the negative active material and the subsequent loss of capacity can be prevented by adding to the active material certain inert substances, like finely divided carbon, lamp black, china clay, etc. Dr. Edward Sokal has found that the reason why such inactive additions prevent the shrinkage of the negative active material is not a changed behavior of the negative active material, but simply the gassing which must occur thereon and around the finely divided particles during the charging operation. That gassing occurs during the charging process is of greatest importance, because at this time it is most needed, as then the dissolution of the spongy lead takes place by reason of the greater concentration of the electrolyte in the pores, and not during the discharge and rest of the battery. Dr. Sokal has now found that lead dust, as a substitute for or combined with finely divided carbon and the other inert materials mentioned above, is very effective. With the addition of lead dust to the negative active material, an ordinary grid with pellets completely filling the compartments, and with a retaining perforated envelope of hard rubber or

lead, the battery works satisfactorily and the contained negative active material does not show any shrinkage. (905,599, Dec. 1, 1908.)

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Modified Blast Furnace Process.—Mr. J. E. Johnson, Jr., of Longdale, Va., who has paid much attention to the use of dry blast (see, for instance, our Vol. IV, page 349), endeavors to go even further than Mr. Gayley. His proposition, made in a recent patent, is a great deal more radical and is very interesting. He removes not only the moisture from the air blast, but most of the nitrogen (which is inert and parasitic in the blast furnace since it consumes heat and carries this heat off without any use), so that he employs a blast chiefly of oxygen. Mr. Johnson's own method of removing the nitrogen from air is not described, but this would not seem to involve insuperable difficulties. Liquefying of air might be used and the cost would not appear to be prohibitive, in view of the possible gains. The chief gain, pointed out by Mr. Johnson, would be the possibility of doing away with the heating stoves for the blast and with many of the accessories. A further equally radical change proposed is the feeding of the carbon and of the iron ore, not together, but in separate columns. The intention is to oxidize the carbon by the oxygen of the blast to carbon monoxide and to force the carbon monoxide through the iron ore, resulting in the reduction of metallic iron and the formation of carbon dioxide. The latter passes off through the ore column and preheats it, but it does not come again in contact with free carbon, which would result in formation of carbon monoxide. In this way more of the carbon can be oxidized to dioxide than in ordinary blast-furnace practice (where only one-third of the carbon is oxidized to dioxide). A better utilization of the calorific value of the coal could thereby be obtained within the furnace itself (the same tendency being marked in modern electric furnace designs for iron smelting). The furnace proposed by Mr. Johnson is shown in Fig. 1. The ore is charged from the platform 20 into the conical hopper 200, and then into the stack. At the center of the hopper 2 is a mantle 40 with hollow artificially-cooled walls; through this mantle the fuel is charged. If the mantle for the fuel and furnace outside of it for the ore were both kept full to an approximately constant height, the proportion between the fuel and the ore charged would be determined by the areas inside and outside of the mantle at its lower end, and the weights of the respective columns of materials above these areas, and would be approximately constant, whether right or wrong, if no provision were made to vary this ratio. The ore, being heavier than the fuel, will tend to cut off the descent of the fuel, and the column of the fuel is, therefore, made higher to compensate for this. The purpose of the piston 48 and pusher 45, which works with a free fit within the cylindrical portion of the mantle 40 and presses upon the fuel, is introduced as an adjustable factor to enable the ratio of the amount of ore and fuel charged into the furnace to be controlled. An important advantage of the method of charging the carbon separately is that it is not necessary to use coke, but soft coal may be used, and there is no trouble due to the pieces sticking together, since, in this case, it is not desired that the gases should percolate upward through the coal. The fuel column being in the center of the furnace is also out of contact with the walls, and, therefore, any possibility of "hanging" by the adherence of the fuel to the wall is thereby prevented. In view of the radical nature of the changes proposed from ordinary practice—which in principle are sound—it would be very interesting to know what results have been obtained on an experimental scale with this arrangement.



BLAST FURNACE.

Vanadium Steel.—Dense steel of great strength and high elasticity, without fissures or cracks, for high-speed tools is obtained, according to W. Ruebel, by melting "chemically pure" iron and nickel, or iron and manganese, or iron and tungsten, and chromium, in such proportions as to represent their atomic weights, and then adding not more than 3 per cent of vanadium carbide. Vanadium alone may be added, if the steel contains the corresponding amount of carbon. "The quantity of vanadium in the alloy should not exceed a certain proportion, 0.3 to 3 per cent being the most favorable." . . . "To obtain, for instance, steel of a strength as to bear 150 kg for each square millimeter and of 10 per cent elongation or extension, the necessary quantity of iron is melted with the nickel, mixing them in such manner as to have 0.9 per cent carbon. In melting the percentage is reduced to 0.5, then 1.05 per cent of vanadium is added, either as vanadium or ferrovanadium, and the alloy is allowed to boil for about two hours. The slag formed absorbs part of the vanadium, leaving but about 1 per cent in the alloy." (906,937, Dec. 15, 1908.)

Zinc.

Zinc from Slag.—The amount of iron and zinc, and also of manganese left in slags from copper and lead smelting, is a problem of commercial importance which has attracted the attention of Mr. Anson G. Betts, the distinguished pioneer of electrolytic lead refining. His method of extracting iron and zinc from slag may also be considered as a new process of zinc smelting; generally zinc ores contain other valuable metals, lead and copper, for instance, and frequently these are separated at some cost and with much loss before smelting. Mr. Betts proposes to omit this preliminary separation, to smelt the ore in substantially the usual manner in blast or reverberatory furnaces, and to recover the zinc, iron and manganese from the slag. For this purpose the molten slag poured into a suitable furnace, treated with silicon or a silicide; ferrosilicon containing sufficient iron to materially increase the specific gravity is suitable. The reactions ensuing are, of course, $2\,FeO + Si = 2\,Fe + SiO_2$ and $2\,ZnO + Si = 2\,Zn + SiO_2$. The iron separates at the bottom of the furnace, while the zinc boils off and is condensed. If the slag contains manganese, most of it is found in the iron, if sufficient silicon is used. To recover zinc from zinc ores, the roasted ore may be added to a copper, lead or other smelting furnace, collecting the zinc from the slag; or the zinc ore may be melted with a suitable slag or flux and the zinc removed by silicon, while part or all of the resulting slag or cinder is returned to the process as a flux for more zinc ore. One pound of silicon reduces about four pounds of iron, or four and a half pounds of zinc. The process is applicable to low-grade materials, "and the necessary energy can be supplied by the cheap combustion of fuel up to a certain temperature, and when the efficiency of energy supply by this means becomes low, at, say, the melting point of ordinary slags, a more expensive but more efficient and convenient supply of energy is only then added, in the shape of silicon." The commercial success of the whole process depends, of course, on the price of silicon; this is an electric-furnace product, and, as is well understood, the cost of silicon depends chiefly on the cost of electric power. (905,280, Dec. 1, 1908.) Mr. Betts has also worked out an analogous process for the recovery of manganese from slags. On acount of the complete analogy it needs no further description. (905,281, Dec. 1, 1908.)

Pyrometry of Continuous Furnace Processes.

BY CHAS. E. FOSTER.

By a continuous furnace process is meant one in which the furnace temperature is kept as steady as possible while the pieces of work under treatment are passed into the furnace and out again in a more or less continuous manner. One of the conditions of such a process is that the furnace temperature is considerably higher than the maximum reached by the work. This being so, the final temperature of the material will depend, firstly, upon the temperature maintained in the furnace, and secondly, upon the time during which the material is subjected to that temperature.

This method of furnace operation is applied to many of the most important operations in the metallurgical industries, and, of course, needs special study.

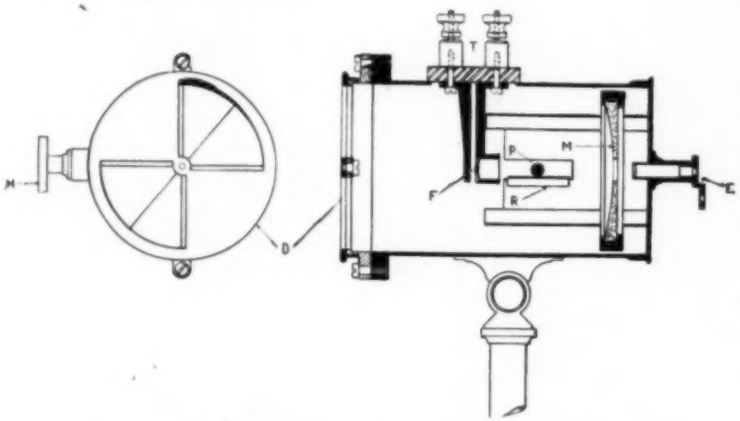


FIG. 1.—FRONT ELEVATION AND SECTION OF FERY PYROMETER.

The highest efficiency will be realized in any case when the furnace temperature is kept continuously up to the safe maximum, while the work is fed through the furnace at the highest speed that secures a sufficient heating to give the desired final temperature. It is in the determination of this safe maximum temperature of the furnace that pyrometry plays such a vital part.

The highest safe temperature will probably be fixed by one of the following considerations:

(a) The maximum capacity of the heating apparatus.
(b) The maximum safe temperature for the furnace lining.
(c) The danger of overheating the outside of the work before the interior gets up to the required finishing heat.

(a) With modern furnaces, oil or gas fired, or worked on a regenerative principle, there should be little difficulty in getting sufficient heating capacity. The amount and distribution of the air supply will be a point requiring careful study.

(b) The highest safe temperature for the fire brick can be ascertained by noting that point of the wall or roof which is hottest and then running up the heat till it is found that the brick begins to flux.

(c) The safe temperature to avoid burning the outside of the work can also be found in a similar way.

Having decided by experiment which of the three conditions gives the lowest limit, then the first of the two main factors is settled. It now remains to determine the highest speed at which the work can be passed through the furnace to come out hot enough for the purpose in view. This is the second and last factor by means of which the highest duty can be got out of a given furnace. There is no need to dwell on the savings in running cost and the increase of output that would result from this method of handling the temperature problem.

In looking at the above outlined series of experiments, it will be seen that they all involve the measuring of temperature. And on closer inspection they all require the measurement of a *surface temperature* and three of them *inside a furnace*. The remaining measurement can be made outside the furnace, but should be on *moving objects* to get the proper working conditions. It is, therefore, evident that the thermocouple of the LeChatelier type cannot be successfully applied. The pyrometer for this work must work quickly and at a distance. The junction of a LeChatelier thermocouple (if it is properly protected as it should be from furnace gases), must be actually raised to the temperature to be measured, and considerable time must be given to secure accurate readings.

To measure high temperatures at a distance we must make use of the radiations given out by the hot body. We may use those that are visible to the eye, as in the optical pyrometer or the whole heat radiation, visible and invisible as in the Fery radiation pyrometer, and the latter is much to be preferred.

The use of an optical pyrometer involves skill on the part of the operator; it depends on the matching of two degrees of brightness, one of them the standard. The standard must be frequently calibrated to insure its constancy and the actual temperature reading is made by reference to a conversion table. Now, all of these considerations render the optical pyrometer a laboratory instrument rather than a works pyrometer.

With the radiation pyrometer invented by Prof. Charles Fery, of Paris, the disadvantages named above are not met. There is no color matching to do and the instrument once pointed is both instantaneous and automatic in its indications of temperature.

In order to show the fitness of the Fery pyrometer for the work in hand a somewhat detailed description of the instrument is given.

In Fig. 1, on the right is shown a longitudinal section of the pyrometer, while on the left is a front elevation.

A certain proportion of the heat radiated by any hot body is caught by the concave mirror *M*, and brought to a focus at *F*. Heat rays can be caught and brought to a focus just as light rays can; in fact, they are broadly the same thing, so that wherever we concentrate light at a focused image, we are also there concentrating heat in just the same way. The "burning glass" forms a heat image of the sun, and the temperature in that heat image is hot enough to scorch a piece of paper.

As the distance is varied between the hot body and the mirror *M*, the size of the focused image varies in the inverse way; for instance, if the hot body has a diameter of two inches and the focused image a diameter of one-sixteenth of an inch, then, if the mirror be moved to half the distance, the same hot body will give a focused image of one-eighth of an inch. Since the heat received and focused by the mirror *M* varies inversely as the square of the distance, the effect of moving to half the distance is to concentrate four times the energy at the focus. But we saw that the diameter of the focused image was then double its first value, hence its area will be four times, and therefore the effect of moving the mirror up to half the original distance is to concentrate four times the heat over four times the area, leaving the intensity just the same. According to these principles the temperature at the focus varies with the temperature of the hot body, but is independent of the distance.

FIG. 2. FOCUSING DIAGRAM.

Now, in order to get a reading, all that is needed is some sensitive means of measuring the temperature at the focus. For the instrument to be sensitive as a whole, this temperature-measuring portion of it must be very sensitive. To make the pyrometer quick acting, the heat capacity of the sensitive part must be very small, so that it heats up or cools instantaneously. Lastly, this sensitive device must be sensitive only to the

temperature of the focused image and not to general air temperatures.

These conditions are correctly fulfilled by the use of a very small and light thermocouple as the sensitive device. This thermocouple is so arranged that one junction is exposed to the focused radiation, while the second or comparison junction is screened from this focused heat. But both junctions are so close together that changes in air temperature affect them both alike. The e.m.f. developed by the thermocouple will therefore depend only on the focused radiation. In order to make the measurement one of *temperature* and not of *total heat* at the focus, all that is necessary to do is to select a portion only of the focused image and to let that portion be a constant area, no matter what the total size of the focused image.

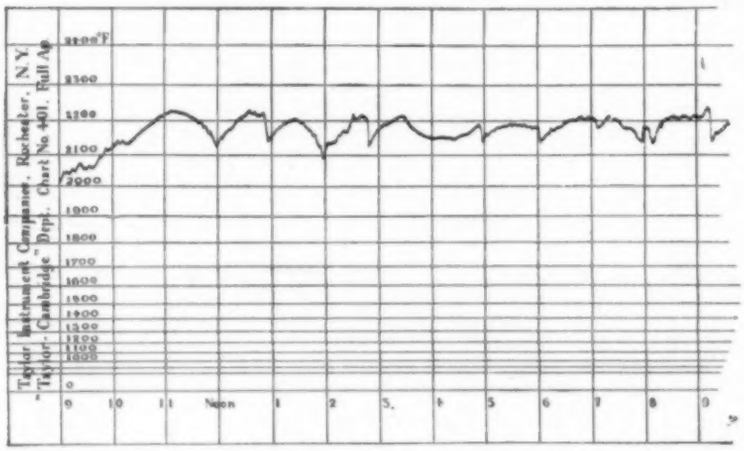


FIG. 3.—RECORD CHART (REDUCED SIZE).

To complete the pyrometer we have now only to provide a means of pointing and focusing and then to use a millivoltmeter to measure the e.m.f. developed by the thermocouple.

The pointing and focusing are done in a very ingenious way. The focused radiant heat reaches the thermocouple junction through a small hole in a diaphragm, and the size of this hole fixes the portion of the focused image that is used to heat the junction. Surrounding the hole, which is at *F*, Fig. 1, are two semicircular mirrors. These two mirrors are set at a slight angle one to another so that, when the observer looks through the eye-piece *E*, he sees an image that is split into two halves. These two halves do not join up properly and match until the focus is correct. In Fig. 2 are shown two views of what would be seen through the eyepiece, that on the left being out of focus, and on the right correctly focused. The focussing is done by the milled head *H*, Fig. 1, which, by means of the rack *R* and pinion *P*, varies the distance between the mirror *M* and the thermocouple at *F*. In order that the measurement may be independent of the size of the focused image, it is necessary that the image shall completely fill the hole in the diaphragm mentioned above. Looking through the eye-piece *E*, Fig. 1, the observer sees the hole as a black spot (see Fig. 2), so that all he has to do is to be sure that the focused image overlaps the black spot all around. Thus, by this simple arrangement, the operator is able to determine at once (1) that the pyrometer is correctly pointed, (2) that it is near enough to the hot body, and (3) that it is focused. These three things, which are all done in one operation, represent the only optical part of the apparatus, the rest of the action being automatic and continuous.

By means of a flexible cable attached to the binding posts *T*, an accurate millivoltmeter is connected in the thermocouple circuit. By calibration on actual high temperatures against accurate standards, the scale of the millivoltmeter not only reads in millivolts, but also in temperature of the hot body. Thus the user has only to watch a pointer moving over a scale to read directly the temperature of the hot body at which the pyrometer is pointed.

In order to give great sensitiveness at medium temperatures, and at the same time to enable very high temperatures to be measured with the same instrument, a very ingenious use is made of an adjustable diaphragm. This is shown at *D* in Fig. 1. When the pointer reaches the top of the scale with the pyrometer fully open, the diaphragm *D* is swung over the mouth of the pyrometer, thus reducing the amount of heat reaching the mirror *M*. In this way the instrument is rendered less sensitive and a second scale is obtained. In the standard instrument the two scales are from 1000° to 2400° F. and 1800° to 3600° F. respectively.

The complete portable outfit includes a collapsible tripod for holding the pyrometer pointed as desired, and also a carrying case to contain the whole outfit.

It will be evident that with this Fery pyrometer the temperature problems indicated previously can be easily dealt with. The pyrometer can be quickly pointed in any desired direction and the user can identify with certainty the object upon which it is sighted. Thus the temperatures inside the furnace may be rapidly explored and the hottest part quickly found. Then the firing may be studied by leaving the pyrometer sighted on the desired part of the furnace and varying the air and fuel supplies. Lastly, the actual temperatures of the work as it passes through the furnace can be accurately measured.

Where the problem calls for continuous recording of the temperatures, the pyrometer may be set up on a steady support and the place of the indicating millivoltmeter taken by a sensitive, autographic recorder called the Thread Recorder. This instrument produces a continuous record in ink in a very simple and accurate manner while avoiding any errors that would arise from pen friction.

If for any reason it is found inadvisable to have an opening permanently in the side of a furnace, the Fery pyrometer can

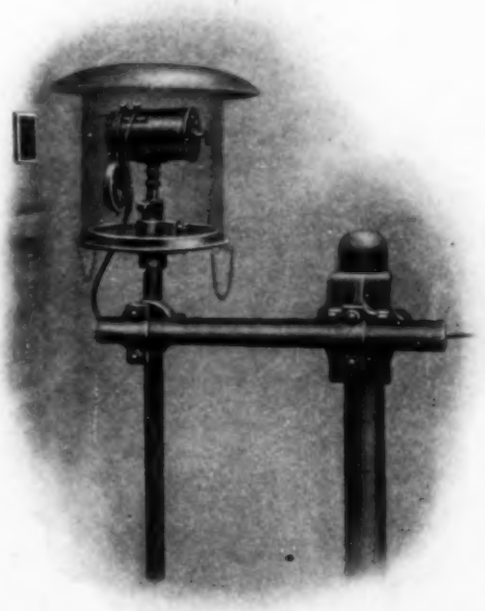


FIG. 4.—FERY PYROMETER WITH BRACKET AND WEATHER-HOOD.

still be satisfactorily used for measuring the temperature of the furnace by the insertion of a tube closed at the inner end through the wall of the furnace. This tube will then take up

the furnace temperature and the Fery pyrometer can be sighted into the closed end. The appearance of the pyrometer under these conditions is protected by a weather-hood. This is shown in Fig. 4.

The cover over the instrument is shown as a ghost, but it is actually of metal and has an aperture in the front to admit the radiant heat, and a slit at the back by means of which the pointing can be verified after the weather-hood is on.

These instruments are now manufactured and sold by the Taylor Instrument Companies, of Rochester, N. Y., as that firm has recently taken over the whole American business of the Cambridge Scientific Instrument Company, of England The whole pyrometric field as covered by the Cambridge instruments is now included under the distinctive title of "Taylor-Cambridge."

A Model Chemical and Metallurgical Laboratory and Testing Plant.

The laboratory and testing plant of Dr. Chas. Theo. Hennig, described in the following article, may be justly called a model plant. They are unique in the scope of the research work which is carried out there, while the equipment has many admirable features. The testing plant is located on East Thirty-fifth Street and the Long Island Railroad, Brooklyn, N. Y.

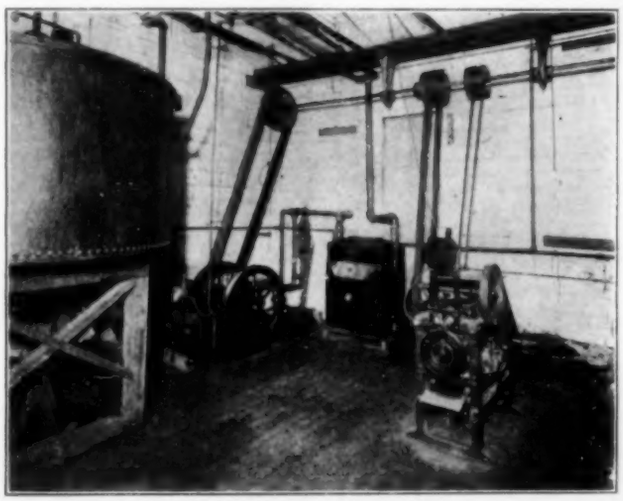


FIG. 1.—MAGNETIC SEPARATOR AND ONE OF THE CYANIDE TANKS.

The research laboratories and the library are located at 1620 New York Avenue, two blocks from the testing plant.

The research laboratory is probably the best equipped of any private laboratory in existence, and contains as complete a set of apparatus as is ever used in metallurgical research. It contains powerful microscopes and some of the most delicate scales in existence, as well as all the apparatus for pyrometry, microscopy, spectroscopy, etc. The library contains over 5000 volumes devoted to metallurgy, chemistry and allied sciences, and has books dating from the seventeenth century to those of the present. (In parenthesis it may be said here that a glance over the illustrations of Agricola's Metallurgy of 1657, which is found in Dr. Hennig's library, brought home to the writer of this note the fact that some mechanical appliances and arrangements, widely used in modern engineering works, are not the result of inventions of the last century, as we sometimes fancy. Some of our forefathers of the seventeenth century were good engineers, too.)

The work carried on by Dr. Hennig and his corps of assistants extends from the isolation of rare minerals to the casting of steel ingots. Dr. Hennig has in his possession 53 elements, most of which have been isolated under his special supervision.

The testing plant is of very wide scope. It is midway between an ordinary laboratory and a large commercial chemical or metallurgical works. It is, in fact, a commercial works on a small scale, so equipped that a whole process may be carried out there, beginning with ore crushing and concentration, fol-

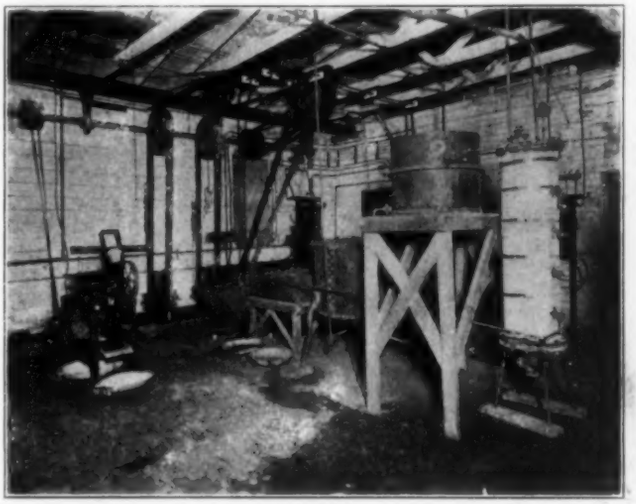


FIG. 2.—LEACHING AND PRECIPITATING PLANT FOR REFRACTORY ORES.

lowed by roasting, smelting, refining, or whatever the metallurgical treatment may be, and ending in a finished product which is submitted to mechanical and chemical tests—all these operations and tests being carried out under one and the same roof.

The equipment of the plant, most of which is interchangeable to allow for the variations in different processes, therefore provides for the following lines: Crushing and sizing (by crushers, stamp mills, rolls, etc.), amalgamation, cyaniding, magnetic separation, roasting, blast-furnace smelting, electric smelting, electrolysis, leaching and chlorination.

It is a pity that on account of the confidential nature of most of the work, we cannot give details of the various researches carried out. But to give an idea of the scope of the work it

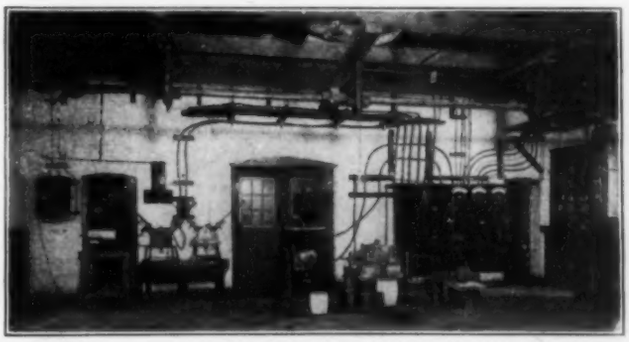


FIG. 3.—ELECTRIC FURNACES.

may be mentioned that it relates, among others, to such different problems as a new process for working complex lead-zinc ores, a new nickel-silicide process, numerous researches on special steels and ferro-alloys and alloys in general, new arc lamps, metallic-filament lamps and incandescent gas lamps.

The building which contains the testing plant has four departments. In the front room are contained a stamp mill; plants for concentrating, cyaniding and leaching; apparatus for

magnetic separation; apparatus for electrolytic work; steam plant for drying purposes; air compressors, etc.

In the central room are rolls, sample mills, crushers, screens, reverberatory furnace, blast furnace (24 in. diameter, 12 ft. high), and a large power hammer for testing steel bars.

The rear room contains several large pieces of machinery, among which is a 75-hp Springfield gas engine. Preparations are being made to install one of 100 hp. Here also are a 60-kw Eddy dynamo and six electric furnaces for the smelting of refractory metals, making carbides and the different alloys of nickel, chromium, molybdenum, tungsten, vanadium, titanium, thorium, etc.

FIG. 4.—ELECTRIC FURNACES AND SWITCHBOARD.

On one side of the building is a room containing a 25-hp White & Littleton gas engine and a dynamo for the small electric furnaces, while on the other side is the chemical laboratory.

The power necessary for the plant as a whole is derived from six gas engines of different makes, ranging from a 3- to a 75-hp, and having a total of 130 hp.

FIG. 5.—CRUSHER.

New Ore Concentrator.

Construction of Concentrating Table.—An interesting novel feature of the testing plant is the Hennig concentrating table, which is the outcome of considerable experimentation with refractive ores that could not be handled by other tables. It has the following advantages:

The driving gear is in one piece and includes fast and loose pulleys, balance wheel and double eccentric drive. Three-quarter horse-power is required to drive the table. The longitudinal oscillations may be varied from 0 in. to 15/16 in.—the rate of the oscillations ranging from 150 to 180 per minute.

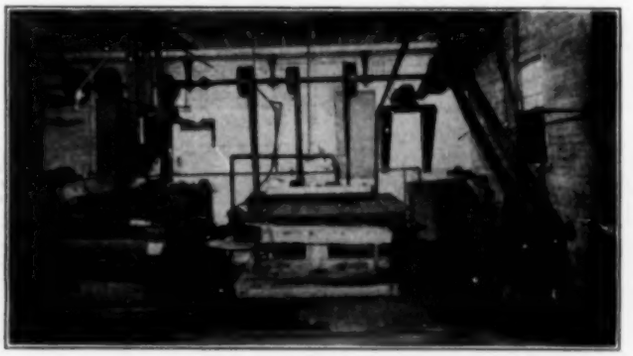


FIG. 6.—CONCENTRATION ROOM.

The riffles are made of semi-circular lead strips—the total length of which is 1256 ft. for each table. Each lead strip is 5/16 in. wide and 3/16 in. high, except when flattened. At the feed end of the table the distance between the riffles is 3 in., while at the discharge end it is only ¼ in. These figures, of course, vary, the variation depending upon the kind and quality of the ore under treatment.

As before said, the riffles are flattened as the discharge end of the table is approached, and this is accomplished by passing the lead strips through a hand-power rolling machine. The lead strips are shaped in a wooden mold.

A special feature of this machine is the arrangement of the riffles in sinuous curves.

The foundation of the table consists of three 5-ft. cross-pieces made of 8-in. x 8-in. timber, and resting on these cross-pieces are two 9-in. channel bars. The table proper rests upon the two cross-pieces, the four corners of which are fitted with short steel pins that have ball ends. These pins work freely in sockets fitted to the ends of the cross-pieces on the bottom of the table.

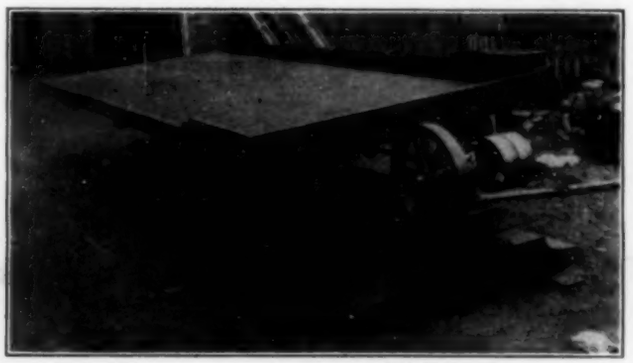


FIG. 7.—COMPLETE TABLE.

Fixed rigidly to the channel bars are the cross-pieces, and projections from the cross-pieces work freely between guides attached to the bottom of the table. The guides may be set at any angle with the line of the driving rod, thus giving to the table the required amount of side motion.

In addition to the longitudinal and the side motion, the table is also capable of a rocking motion, which motion is imparted

by the ball-and-socket arrangement. Taking all these movements into consideration, the motion of the table when in operation is very similar to that imparted by the prospector to the ordinary pan.

The feed trough is 15 ft. 7 in. long, 3 in. high, 8 in. wide at the feed end, and 3 in. wide at the discharge end. Gate-like partitions divide the trough into five compartments, the gates consisting of a strip of wood that can be raised or lowered and fixed in any position. The gates are capable of adjustment so as to leave a space anywhere from 1/16 in. to 5/16 in. The pulp is charged onto the table through holes placed 2¼ in.

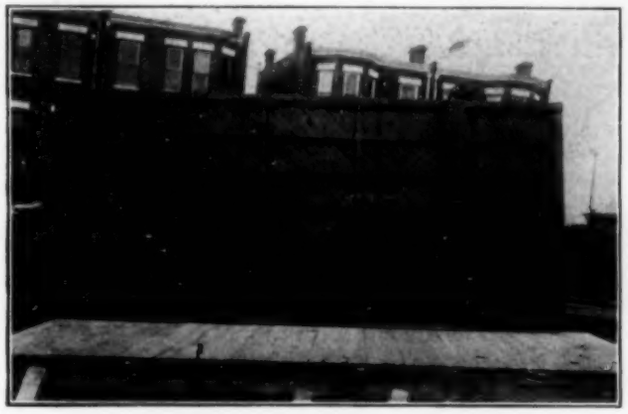


FIG. 8.—BOTTOM OF TABLE.

apart in the outer side of the feed trough. At the feed end of the table these holes are ¾ in. in diameter, while those at the discharge end are only ⅜ in. The feed trough is capable of adjournment to within 0.001 in.

Operation of the Table.—The ore is allowed to pass into the wide end of the trough at the head of the table. The gates being adjusted, a concentrating effect is obtained by the grooves in the bottom of the trough, and the mineral portion of the feed collects in the groove and passes on toward the discharge end

FIG. 9.—HEAD MOTION OF TABLE.

of the table. The overflow from each compartment passes by means of the holes referred to onto the table proper. The quality of the pulp feed through the holes and the fineness of the concentration in the feed trough depends upon the inclination of the trough and the space left under the gates.

By this arrangement about 90 per cent of the concentrates are made in the trough, only the balance of the pulp passing over the table. Through the agency of the curved riffle and the gyratory motion of the table the pulp is washed at every curve and within the arc of each curve, thus making the concentrating process continuous over the entire length of every riffle. The average capacity of the table is about 50 tons per 24 hours.

Our thanks are due to Dr. Hennig for the information con-

FIG. 10.—SUBSTRUCTURE AND TIPPING ARRANGEMENT.

tained in this article and for many courtesies shown to the writer during a whole afternoon's visit to the laboratory and testing plant.

Ozone for Purification and Regeneration of Air.

The Siemens & Halske Co. of Germany have paid for many years great attention to the production of ozone by the silent electric discharge. The late Werner Siemens was a pioneer in this field as in so many others. It is well known that while the fixation of atmospheric nitrogen (that is, the combination of the nitrogen and oxygen contained in ordinary atmospheric air) essentially requires an arc or spark discharge, the transformation of oxygen into ozone requires the so-called silent

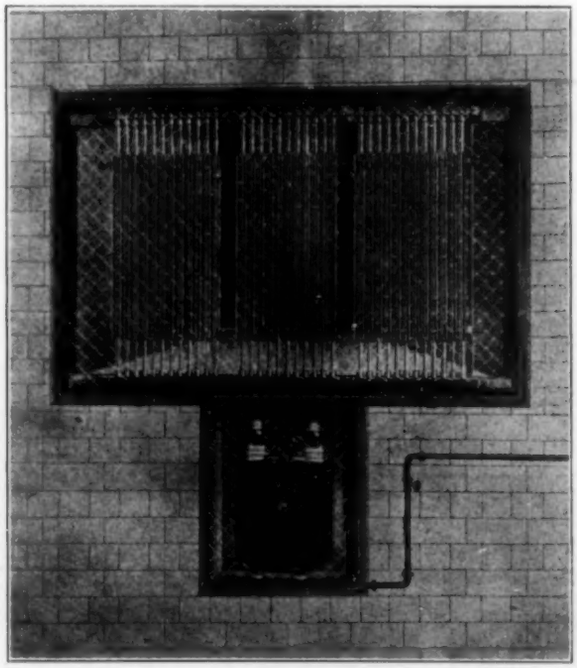


FIG. 1.—OZONE VENTILATOR.

discharge and the formation of an arc would be fatal. While the combination of the nitrogen and oxygen to nitrogen oxide due to the arc is, to a large extent at least, a thermal phenomenon, the formation of ozone, which may be represented by the equation of $3O_2 = 2O_3$ (the two-atomic oxygen molecules being changed into three-atomic ozone molecules), appears to be a specific electric phenomenon, the exact nature of which is not yet fully understood, although a photo-electric effect due to ultraviolet light seems to be involved.

Whatever the theory, ozone has proven very successful in

practice under the care of the Siemens & Halske Co. It is unnecessary to describe in detail again the old and well-known Siemens ozonizer (see our Vol. 1, page 179). It is of the well-known tube construction with glass as dielectrics. In the past the Siemens & Halske Co. have pushed the use of their ozonizers especially for two purposes.

One was the treatment of ordinary starch with ozone yielding a peculiar product, the "ozone starch," which with its properties stands midway between starch and dextrine. Like true starch, ozone starch is insoluble in cold water, but dissolves in hot water without forming a paste like dextrine. For this property ozone starch is used extensively as a binding material for paints and colors and for printing on cloth, linen and all kinds of fabrics.

FIG. 2.—PORTABLE OZONE VENTILATOR.

The second and even more important industrial application has been sterilization of drinking water. Ozone apparatus for this purpose are made for use in houses and hospitals, and have found a ready sale, especially at times of epidemics. That, however, the use of ozone on a large scale for sterilizing the drinking water of a whole town is commercially possible is proven by the city of Paderborn, in Germany, which has been equipped with ozone apparatus for some five or six years. These have been in continuous use and it is a significant fact—not a theory—that the typhoid epidemics which came at regular intervals before, have now absolutely ceased since the introduction of the ozone treatment.

Quite recently, however, the Siemens & Halske Co. are using their ozone apparatus also for the purification and regeneration of the air. The fundamental fact is that the strong oxidizing nature of ozone is able to regenerate foul air even without the supply of fresh air. Of course, ozone may also be used in combination with fresh air supply. The ozone molecules give off their third oxygen atom, which oxidizes the impurities in the air, while the remaining bi-atomic oxygen molecules bring up again the air to the desired concentration of oxygen.

For this purpose it is not necessary to use a high ozone concentration. Practice has shown that with 0.05 to 0.5 gram of ozone per cubic meter the desired deodorizing and purifying effect is obtained.

If the building (or mine, etc.) is equipped with a ventilating system, the ozonizers are simply inserted in the air-ventilating shafts. Fig. 1 shows the arrangement of the ozonizer of the Siemens & Halske Co. for this purpose. It consists of alternating metallic rods and plates, forming the two opposite poles connected to the high-tension side of the auxiliary transformer, which is part of the ozonizer and one pole of which is earthed for the sake of safety.

The metallic rods are enclosed in glass tubes forming the dielectrics which causes the silent discharge and prevents the arc discharge. The air passing through the ozonizer is ozonized and is then supplied through the ventilating system to the different rooms of the building. The consumption of energy is relatively low. Apparatus for ozonizing 1000 to 5000 cubic meters of air per hour require about 30 to 150 watts.

If the building is not equipped with a ventilating system, different methods are possible. Fig. 2 shows a portable ozone-ventilator which may be placed in any room. In this case, of course, there is no supply of fresh air, but only regeneration of the old foul air, as explained above. The apparatus is connected to the electric wiring system, just like a lamp or a motor. Of course, this presupposes that the supply system is alternating current; otherwise a small converter or motor-generator is necessary.

Fig. 3 shows an ozone ventilator which is inserted within a hole in the wall, the fan driving fresh air from the outside into the room. The largest part, however, of the air is pressed through the ozonizer and thereby ozonized. When ozonizing 10 to 90 cubic meters of air per minute these ozone ventilators consume about 175 to 900 watts, including the power necessary for driving the fan.

These ozone apparatus have proved useful for ventilating factories, workshops, storerooms, meat packing houses, theaters and meeting halls. Particularly useful they have also proven in the case of a tunnel railroad and on board ship, and there is no doubt that they could also be advantageously employed for ventilating mines, although, of course, in the case of coal mines the danger of explosions would be prohibitive.

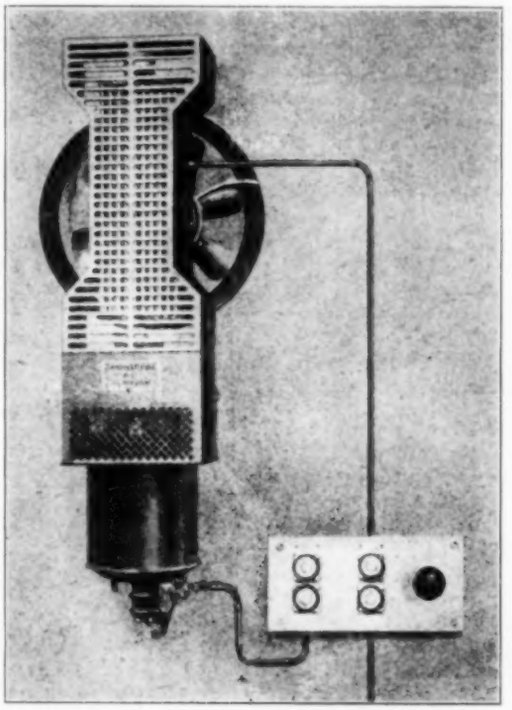


FIG. 3.—OZONE VENTILATOR IN WALL.

These apparatus are now being introduced in this country by the American branch office of the Siemens & Halske Co. and the Siemens-Schuckert Co., in charge of Dr. K. G. Frank, Room 1559, Hudson Terminal Building, New York City.

A New Departure in Pyrometer Design.

An interesting, self-checking pyrometer, radically different from previous types, has recently been developed and placed on the market by the Leeds & Northrup Co., of Philadelphia.

It is especially intended for use where it is desired to hold the temperature of an oven, vat, etc., at a given value, and for this class of work, combines the accuracy and constancy of a Wheatstone bridge measurement with the ease and convenience of a deflection measurement.

The pyrometer consists of two parts: the bulb or fire-end, and the indicator. The bulb is a coil of platinum wire, enclosed in suitable porcelain or quartz tube, protected by seamless nickel tube. The indicator consists of a Wheatstone bridge, mounted on the base of a regular switchboard-type ammeter. It operates on any direct-current system, and is practically independent

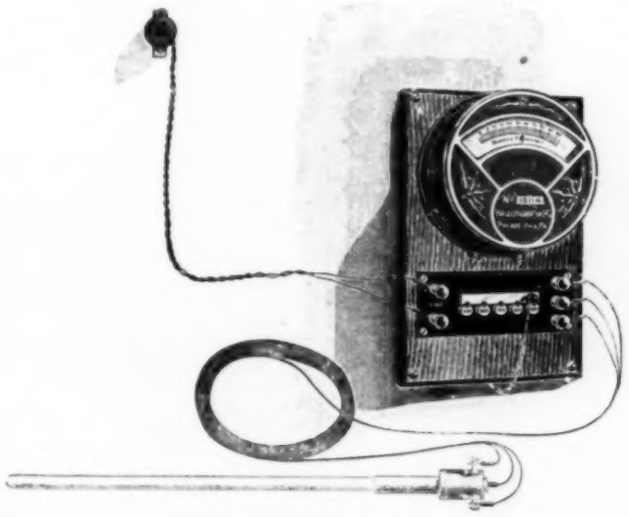
of voltage fluctuations in the supply. Any number of bulbs located at any distance may be read on one indicator through a suitable switchboard.

Owing to the fact that the energy used in the electrical system is supplied from an outside source, the amount may be made as large as is used by a regular switchboard ammeter. A regular stock ammeter, without shunt, is used, and hence this instrument is as heavily constructed, as robust, as reliable and as constant as a switchboard ammeter.

The constancy of the platinum resistance bulbs is shown by tests made by the National Bureau of Standards. Resistance bulbs in practically constant use for over two years at 1800° Fahr. show a change of less than 6° Fahr.

The regular indicator is supplied with a 5-in. 220° Fahr. scale, and has extension plugs to extend the range to 1000°, thereby giving the instrument the equivalent of a scale 25 in. long. It is available for any range below 1800° Fahr.

Due to an overlapping scale, this instrument may be checked up at four points throughout its range without disturbing any part of the apparatus.



PYROMETER.

As is above stated, the instrument employs the Wheatstone-bridge method. At one point for every 200° of its range, the Wheatstone bridge is balanced and the readings of the instrument are independent of calibration of the ammeter.

This balance point is placed in the center of the scale. If the ammeter, due to any cause, is 3 per cent off calibration, the error in the temperature is 3 per cent of 100°, or 3°. If the temperature, being measured, is 1800°, the error due to the reading instrument would be 3°. All the conventional types of electrical deflection pyrometers have the galvanometer scale cut to cover the entire range. If such an instrument had its galvanometer off calibration by 3 per cent, its error at 1800° would be 54°.

To look at the principle of the instrument somewhat differently, the great bulk of the measurement is made on the Wheatstone bridge, the ammeter taking the residual, consequently, an error in the ammeter only affects the measurement of the residual, which equals only 100°. Constructed as it is of non-movable, perfectly protected standard resistance coils, nothing short of absolute and wilful abuse can injure the Wheatstone bridge. From the fundamental principle of the bridge, it is independent of the voltage of the circuit which supplies the energy.

This balance point may be placed at such values as will best adapt the instrument to the needs of the user, and will then indicate departures from this temperature so clearly that a workman can stand at a considerable distance from the indicator and clearly note if the temperature is too cold or too hot.

The portable type of indicators made by this company are entirely independent of the calibration of a galvanometer. The measurement is made on a scale 16 in. to 25 in. long, located on a circle 6 in. to 8 in. in diameter, the galvanometer merely indicating when the operator has turned the index to the proper position on the scale. With this type of instrument, which has been, for some years past, used in many industrial establishments, in the hands of men unable to read English, the Leeds & Northrup Co. are prepared to guarantee an accuracy of 5° at 1700° Fahr.

Transport of a Tube Mill.

The installation of mining and metallurgical machinery in out-of-the-way places often involves considerable difficulties. In many cases these can only be overcome by special construction

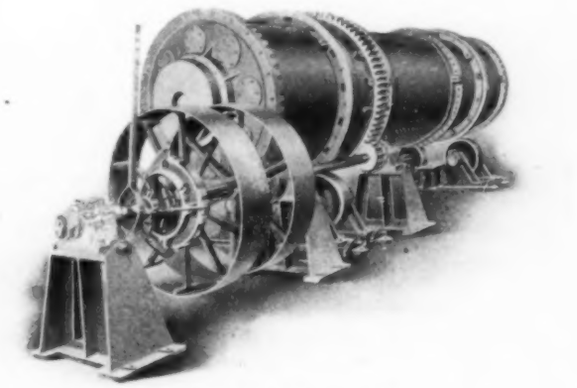


FIG. 1.—TIRE-STYLE TUBE MILL.

of the machinery in sections which permit easy transportation.

An interesting instance of this kind is the construction of four large tube mills, built by the Abbé Engineering Co., 220 Broadway, New York City, for the Ventanas Mining & Exploration Co., of Mexico. These tube mills are 4 ft. 6 in. in

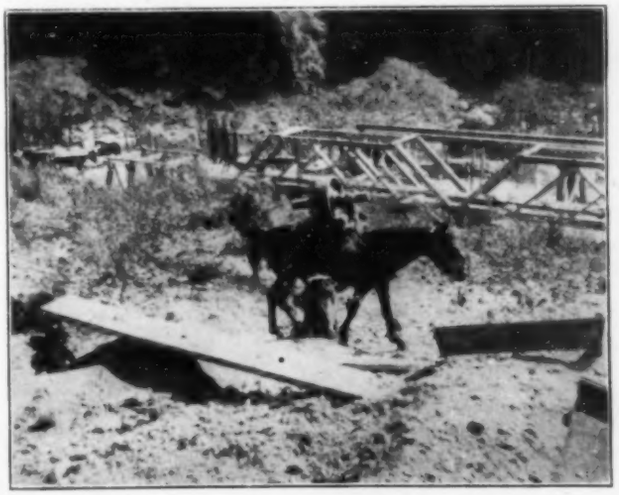


FIG. 2.—MULE WITH SUPPORTING ROLLER.

diameter and 18 ft. 5 in. long, and each weighs complete 51,000 lb. This weight is made up of 26,000 lb. of metal work, 16,000 lb. of selected flint pebbles, and 8900 lb. of silex lining.

As these tube mills had to be transported to the mine on mule back, they had to be sectionalized. Fig. 1 shows one of these sectionalized tube mills, tire style (patented), as set up complete in the erecting shop of the Abbé Engineering Co. before being knocked down and shipped. Since the construction of the tube mill of this company, with its characteristic feature of spiral charge and discharge, has been described and illustrated repeatedly in this journal (see, for instance, our Vol. III, page 41), there is no necessity to describe it again in detail.

The heaviest pieces of this sectionalized machine are part of the "Ideal" spiral feed, weighing 400 lb.; 12 pieces of shell weighing 340 lb. each; the four chrome-steel rollers, weighing

FIG. 3.—MULE CARRYING ONE-HALF OF A LOCOMOTIVE STEEL TIRE.

375 lb. each. Several other pieces weigh 350 lb. each, while the balance of the pieces weigh less than 300 lb. each.

Fig. 1 shows a mule carrying one of the four chrome-steel supporting rollers, on which the mills revolve.

Fig. 3 shows a mule carrying one-half of one of the two locomotive steel tires (four pieces), which surround the mill and which turn on the four rollers above mentioned.

FIG. 4.—MULE WITH PIECE OF SPIRAL FEED.

Fig. 4 shows the largest piece of the spiral feed on the first mule and a chrome-steel roller on the second mule.

Fig. 5 shows 20 mules carrying the different pieces of one of the tube mills on their backs.

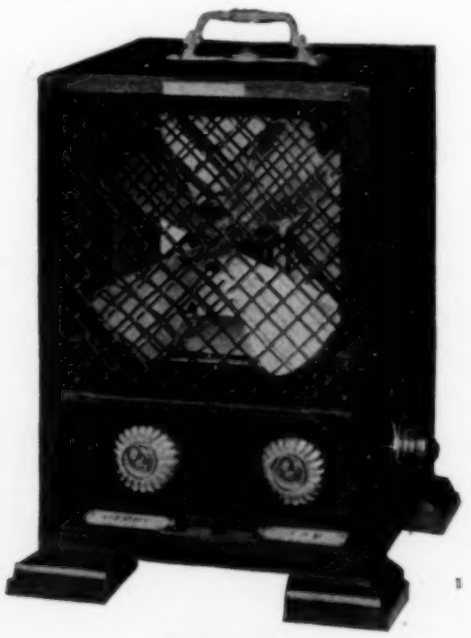
These Abbé tube mills are the largest that have ever been sectionalized in such small pieces, this being practical only with a tire-style machine. These mills at the Ventanas plant have

FIG. 5.—TWENTY MULES CARRYING ONE TUBE MILL.

now been in operation for some months and are giving entire satisfaction.

New Commercial Ozonizer.

Ozonair Co., Ltd., of London, have placed on the market a new apparatus for the commercial production of ozone by the silent electric discharge. The discharge takes place between two surfaces of metallic wire gauze, oppositely changed from a high-tension alternating-current transformer, while a plate of mica or micanite acts as dielectors. The chief feature claimed for



OZONIZER FAN.

the apparatus is complete freedom of the ozone from any nitrogen oxides (which would be formed immediately if there was any spark or arc discharge).

The principle of the construction is that each corner of mesh of the metallic-wire gauze represents a point from which a silent discharge starts. As there are an immense number of such points on the surface, the silent discharge is distributed over the whole electrode surface, being very finely subdivided. The air is forced to pass over the whole surface and the oxygen is thereby changed to ozone, the plate acting at the same

time like a baffle plate, forcing the air into the desired path.

Ozonizers are built by the Ozonair Co. for purifying air in houses, hotels and hospitals; for sterilization of water and for all other purposes for which ozone, on account of its strong oxidizing and bleaching effect is suitable (bleaching fabrics, bleaching flour, sterilization in laundries, food preservation, maturing of wines and spirits, etc.).

The company pays special attention to the applications of ozone in breweries. One application is to avoid the liability of the yeast to become "weak" or to be affected by atmospheric influences during the fermenting process, and also in the subsequent yeast storage, thus giving a uniform article all through the year. In addition to sterilizing the air and ridding it of all harmful micro-organisms, the purified air is passed on to the wort enriched by the addition of free ozone, which has the effect of invigorating the fermentative action and of strengthening and improving the yeast. For cooling and refrigerating, the objects are somewhat similar, viz., to rid the air of all the solid impurities, and afterward to sterilize it. This is an important feature, as during these processes of cooling or refrigerating, the wort is exposed to the air in very thin layers, and it is thus much more susceptible to the action of the harmful micro-organisms and germs than in any other of the processes of brewing. In bottling with the aid of compressed air it is also necessary to use pure air, and in addition, if the top layer which is left in the bottle be strongly ozonized, there will be no liability of the beer to go bad. The company have installed an apparatus for the above purpose in a large London brewery; it has now been working for considerable time with complete success.

The ozonair apparatus are now being introduced in this country by Mr. A. W. Beuttell, 133 Fifth Avenue, New York City. The adjoining illustration shows an ozonizer apparatus for purification of air in houses or hospitals; the air is ozonized by the silent discharge taking place in the apparatus when connected to an alternating-current supply and the ozonized air is blown into the room by means of a small fan.

Duty on Ferro-Alloys.

The old controversy concerning the duty on ferroalloys has come up again at the recent tariff hearings before the Ways and Means Committee in Washington.

In the past ferrosilicon and ferromanganese has been taxed at $4 per ton, according to paragraph 122 ("iron in pigs, iron kentledge, spiegeleisen, ferromanganese, ferrosilicon, wrought and cast scrap iron, and scrap steel, $4 per ton").

Other ferroalloys, especially ferrotungsten, ferromolybedenum, ferrochromium, and ferrovanadium, were not specifically mentioned in the tariff. Hence the controversy between Government and American manufacturers on one side and importers on the other side. This has now lasted several years.

Mr. Evart Brown, representing the Electro Metallurgical Company at the hearing, summed up the controversy as follows: It was claimed, on behalf of the Government and the Treasury Department, that the logical place for ferrotungsten, etc., was in paragraph 183, which provided for "metals unwrought"; and it seemed to the Government that that clearly covered them, and that a duty of 20 per cent ad valorem should be put upon them accordingly. The importers, however, claimed that that expression, "metals unwrought," did not cover these articles; that, therefore, there was no niche for them in the tariff act, and that consequently they became non-enumerated articles, and in so becoming non-enumerated articles, they became subject to what is called the "similitude clause"; that is section 7 of the present tariff act, which provides that when an article is not enumerated in the tariff act it shall be classified and take duty according to the article which it most resembles in material, quality, texture and use.

They claimed that while these articles were not enumerated they were similar to ferrosilicon and ferromanganese, enumerated in paragraph 122, and that, therefore, they took a duty of $4 per ton.

The case went into court in New York, and it was there held by the Circuit Court of Appeals for the Second Circuit that the expression, "metals unwrought," covered only metals capable of being wrought, and that it must be such a metal as could be made in and by itself into utensils or definite, particular objects; and that the use of a metal to melt up with other things to make a compound to perfect the compound or for some similar purpose was not such a purpose as could enable an article to be called a "metal unwrought."

That distinction was temporarily accepted by the Treasury Department, and all these ferroalloys came in at a rate of duty of $4 a ton. But consequently the Circuit Court of Appeals in Philadelphia in the Third Circuit, in another class of goods somewhat similar, to wit, tungsten metal (not ferrotungsten, but tungsten alloyed with iron), held differently on the proposition of what the term "metals unwrought" meant; and the Treasury Department determined to try a new case on the subject to secure what it thought was a reasonable rate of duty.

Mr. Brown emphasized that in 1897, when the tariff act was passed, almost all the ferrosilicon was low-grade ferrosilicon made in the blast furnace. This is, of course, much cheaper than high-percentage ferrosilicon made in the electric furnace. Further, ferrotungsten and ferrovanadium are very much higher in price. The Electro Metallurgical Company asked that a duty of 20 or 30 per cent ad valorem should be placed on all ferroalloys.

The Primos Chemical Company asked that on ferrotungsten, ferromolybdenum, ferrovanadium, tungsten metal, molybdenum metal and their salts, a duty should be placed not less than 35 per cent ad valorem; further, on tungsten ore, which is now on the free list, a duty of 20 per cent ad valorem. Molybdenum and vanadium ores could also be produced in large quantities in the United States if they were protected by a duty of 10 to 20 per cent to induce their production in the United States. As the manufacturer of high-grade steels is so closely dependent upon the alloys and metals in question they should also be considered, and either an ad valorem duty provided for steel valued at above 16 cents per pound or such other provision as would protect this new industry.

On the other hand, Mr. John L. Cox, representing the Midvale Steel Company (as a very large consumer of ferroalloys in the production of special steels), asked to have the tariff on ferrotungsten removed.

Conical Pebble Mill.

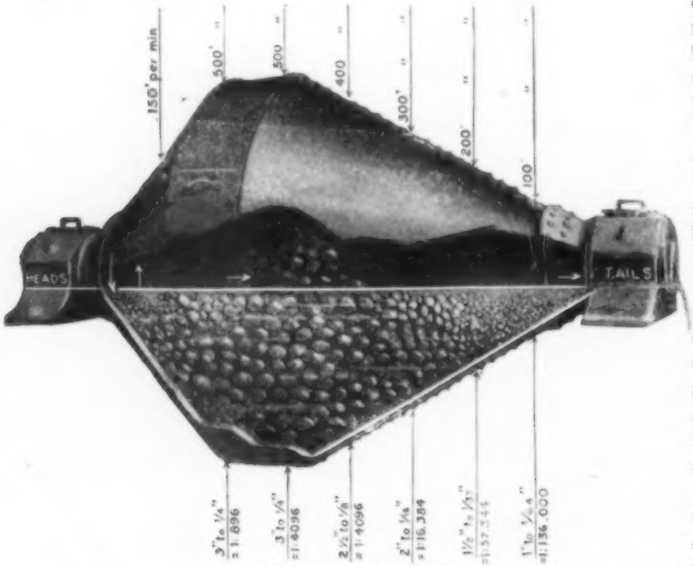
A novel and very curious departure in the design of pebble mills is due to Mr. H. W. Hardinge, who described it in a paper presented at the Birmingham meeting, October, 1908, before the American Institute of Mining Engineers. The Hardinge conical mill, which has already proven successful in practical operation, is being placed on the market by the Hardinge Conical Mill Co., 43 Exchange Place, New York City.

As the name says and the adjoining illustration shows the prominent feature of the design is that it is of conical and not of cylindrical shape. The result of this design is a sizing action, whereby the pebbles and the particles of material to be crushed arrange themselves according to their size at different sections of the cone. The illustration shows the comparative peripheral speeds in feet per minute at different sections of the mill, and a diagrammatic comparison of the size and weight of the crushing pebbles and the particles to be crushed. The great increase in the difference as the sizes decrease is comparatively equalized by the diminished fall and reduced peripheral speed.

Or, in other words, the principles involved of gradual reduction in the same apparatus through the application of a com-

bination of the laws of gravity and centrifugal force, result in classified zones of crushing pebbles and particles to be crushed. A device is thus produced which, while revolving with the same speed in revolutions per minute, contains a multiplicity of zones with gradually changing peripheral speeds.

The novelty of the action raises the question as to the main cause of the sizing. But whatever the ultimate cause may be, the result of this sizing effect is that large pebbles pound on large particles of the material to be crushed with a high momentum, and smaller pebbles on smaller particles with a less momentum. Mr. Hardinge says the principle of crushing in his mill is to use a nail-hammer upon a nail and a tack-hammer upon a tack, i. e., to adjust the power and mechanism to the work desired. This results not only in great uniformity of the ground product, but in a great reduction of the power required for grinding.



CONICAL PEBBLE MILL.

The following results were obtained by the Cobalt Central Mines Co., at Cobalt, Ont., in a series of screen tests on the same ore (diabase gangue) extending over a period of several days. They show the adaptability of the Hardinge mill to fine and coarse grinding for cyaniding or concentration.

	Per cent on Mesh. 8.	Per cent on 14.	Per cent on 20.	Per cent on 40.	Per cent on 60.	Per cent on 80.	Per cent on 100.	Per cent through 100.	
Heads..	16.7	45.1	6	13.9	6.8	4.4	.3	7	
Tails...	..	..	4.8	9.8	22.8	22.3	.9	39	First adjustment.
Tails...	..	..	..	1.3	8	27.5	2.5	60	Second adjustment.
Tails...	..	..	..	..	1.4	10	2	87	Third adjustment.

The average capacity was above 2 tons per hour; the power required, 12 hp to 15 hp; charge of pebbles, 2000 lb.; consumption of pebbles, 1/3 lb (¼ c) per ton of ore.

The total weight of a conical mill (except the lining), having a capacity of from 2 to 4 tons of material per hour, is 8500 lb., and the floor space occupied is 7 ft. x 10 ft. The charge of pebbles is about 2000 lb., and the power required for operation is from 12 hp to 15 hp. These mills can be arranged singly, in series or in tandem, and the large amount of aeration which takes place during the crushing suggests promising results in cyaniding ores during crushing, which, if attained, will greatly simplify present milling practice.

Electric Annealing and Tempering Furnaces.

The electric annealing and tempering furnace, using an electrically-heated fused-salt bath (as described in detail in our Vol. IV, p. 367; Vol. V, p. 428, and Vol. VI, p. 410), has such evident advantages that though only a comparatively small matter in the whole electrometallurgy of steel, it will undoubtedly find a very large field of usefulness. It has already proven successful and reliable in many installations abroad; its chief advantages are the possibility of adjusting the temperature exactly and easily, the fact that the temperature throughout the whole furnace is almost absolutely uniform, and the simplicity of construction and operation.

This furnace has now been placed on the market in this country by the General Electric Company. We reserve a detailed description of the furnace for our next issue.

Notes.

Electrochemistry at the International Congress of Applied Chemistry.—A note on the organization of the Seventh International Congress of Applied Chemistry, to be held in London from May 27 to June 2, will be found on page 7 of this issue. On going to press, we are informed that papers for section 10 (electrochemistry and physical chemistry) should be sent before March 15 to some member of the American Committee of this section: W. D. Bancroft, C. A. Doremus, F. A. J. FitzGerald, L. Kahlenberg, E. R. Taylor, W. R. Whitney. The membership fee of $5 to the Congress is exceedingly small, in view of what subscribers are to receive—the full Transactions of the Congress, consisting of four to seven volumes. It is important that American electrochemists be well represented in the Congress.

The **Westinghouse** Diary for 1909, just issued by the Westinghouse Electric & Mfg. Co., contains again some new and interesting reading matter on engineering novelties, especially on high-pressure and low-pressure steam turbines, the new Leblanc condenser, mechanical stokers, turbo pumps and blowers, tungsten lamps, etc. It is well edited and, in spite of its small size, it gives much useful information on general subjects, including maps, postal regulations, census figures and a list of good hotels in leading cities.

Ozone for a City Water Works.—The City of Taderborn, in Germany, which has had for the past seven years a Siemens ozone plant in continuous operation in connection with the municipal water works, have placed an order with the Siemens & Halske Co. to enlarge the plant so as to double the capacity. One million gallons of water will be purified per day by ozone. This city formerly suffered from periodic typhoid epidemics, which have now completely disappeared.

Duty on Aluminium.—At the recent hearing of the Ways and Means Committee in Washington, Mr. Arthur B. Davis, general manager of the Aluminum Company of America, appeared to urge the retention of the present duty on aluminium, chiefly for the following reasons: During the last four or five years the producing capacity of aluminium abroad was confined to five companies, and these companies were hardly able to supply the demand outside of the United States; but in the fall of 1907 and in the spring of the year 1908, seven more companies started almost simultaneously, and at the same time the five old companies finished large additions to their plants. "The manufacturing capacity by means of these additions and these new plants is about six times the normal consumption of the Continent, and these foreign manufacturing companies are looking to the American market in order to get rid of their surplus product, and so far as we can see there will be no let up to their invasion on this market, and every sale that we make, every quotation that we make, is now made in direct competition with the foreign producers."

Welding of Aluminium.—A few years ago we noticed Mr. W. U. Schoop's new process for welding aluminium, of which he gave a demonstration at a meeting of the New York section of the American Electrochemical Society. The flux used by him for producing an autogenous welding was kept a secret at the time, but has become known through his British patent 24283 of Nov. 26, 1908. According to this patent, the flux is made by adding fluorides of calcium, potassium or boron to a mixture of chlorides of alkali metals.

Aluminium Solder.—Two new solders have recently been patented. H. B. Lambert uses a solder in bar form which is said to be comparatively inexpensive. It consists of 68 per cent by weight of tin, 29 per cent of zinc, 2 per cent of antimony and 1 per cent of phosphorous. (906,637, Dec. 15, 1908.) Another solder is patented by C. G. Carroll and W. H. Adams. It is an alloy of 5 per cent calcium, 47½ per cent tin and 47½ per cent lead. "The combination of the calcium with the other metals produces an alloy whose oxide is formed with a greater evolution of heat per chemically equivalent quantities than are the oxides of aluminium or other metals to be soldered and hence is capable of reducing the oxides of the metals to be soldered through an application of heat while the filling material is capable of attaching itself securely to the surfaces to be joined." (906,383, Dec. 8, 1908.)

Personal.

Dr. **Axel Appelberg**, of the General Electric Co., after a trip through the West, has sailed for Sweden.

Dr. **Eugene Haanel**, accompanied by his son, Mr. B. F. Haanel, has sailed for Sweden to examine a new electric furnace for the smelting of iron ore. This furnace is the outcome of the researches of three Swedish electrometallurgical engineers who have studied this problem for the last three years for a Swedish syndicate interested in iron ore deposits. Dr. Haanel's report to the Canadian government on the results obtainable with this new furnace will be the third of his reports on electric iron and steel processes, his former two reports having marked a new epoch in the electrometallurgy of iron and steel.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electric Furnaces.

(*Continued from Vol. VI, page 523.*)

577,493, Feb. 23, 1897, Francis Jarvis Patten, of New York, N. Y.

Resistance type. The furnace is a circular vertical shaft, having a carbon lining resting on a metal ring which is connected to one terminal of the dynamo. A vertical carbon pencil is supported centrally within the furnace chamber, resting on a porcelain plate. Horizontal carbon-pencil resistors extend radially between the central carbon rod and the carbon lining, being preferably arranged spirally from top to bottom of the furnace. The charge mixture, e. g., lime and coke, is filled into the chamber and around the resistors. The electric current should be in sufficient quantity to melt the resistors, or at least bring them to incandescence, and is passed either successively or simultaneously through the several resistors, around each of which a nugget of carbide is formed.

579,324, William S. Hadaway, Jr., of New York, N. Y.

Resistance type. Muffle furnace especially for firing porcelain. Above the arched top of the muffle is a concentric perforated fire-clay shell. The muffle and shell are enclosed in a rectangular fire-clay box *F*. The space in the box over the top of the shell is filled with a broken carbon resistor, having carbon block connections at its ends. In use, marsh gas is blown through a pipe into the carbon resistor and air is simultaneously introduced through the space between the muffle and shell and through the perforations in the shell, while electric current is passed through the resistor. The marsh gas is partially decomposed depositing carbon in the resistor and lowering and equalizing its resistance. The gas is also burned by the air, so that the muffle is heated both electrically and by combustion.

579,597, March 30, 1897, Arthur J. Moxham, Johnstown, Pa.

Resistance type. Furnace for heating blooms. The furnace comprises a vertical casing of fire-brick having a hinged cover—an arch of fire-brick held in metal. The casing and cover are lined with a thick layer of asbestos or magnesit. A wire coil resistor is partially imbedded in the inner surface of the asbestos linings. A pipe for supplying a reducing gas leads into the bottom of the chamber, and a pipe opening to a safety valve leads from its side.

582,721, May 18, 1897, James A. Deuther, Boston, Mass.

Electrode for arc-type furnaces. The electrode consists of three superposed cylindrical sections, the upper of magnesia and the two lower of carbon or a mixture of carbon and an alkaline earth. The lower sections are electrically connected by imbedded metal pins and conductive cement. The upper section is centrally perforated and receives a metal rod, the lower end of which is imbedded in the intermediate carbon section. The magnesia sheath section protects the terminal rod from the heat. The lowermost carbon section may be renewed as required.

NEW BOOKS.

THE WORLD'S GOLD: ITS GEOLOGY, EXTRACTION AND POLITICAL ECONOMY. By L. de Launay. 274 pages. Bound in cloth. Price, $1.75 net. New York: Putnam.

A MANUAL OF PRACTICAL ASSAYING. By H. Van F. Furman (revised by W. D. Pardoe). 508 pages. 8°. Bound in cloth. Price, $3. New York: John Wiley & Sons. 1908.

THE ELEMENTS OF PHYSICAL CHEMISTRY. By J. Livingston Rutgers Morgan. 548 pages; figures. 12°. Bound in cloth. Price, $3. New York: John Wiley & Sons.

QUANTITATIVE EXPERIMENTS IN GENERAL CHEMISTRY. By J. Tappan Stoddard. 221 pages. Bound in cloth. Price, $1. New York: Longmans, Green & Co.

MINERALOGY SIMPLIFIED: EASY METHODS OF IDENTIFYING MINERALS, INCLUDING ORES, BY MEANS OF THE BLOW-PIPE, BY FLAME REACTIONS, BY HUMID CHEMICAL ANALYSIS AND BY PHYSICAL TESTS. By H. Erni. 444 pages. Leather binding. Price, $2.50 net. Philadelphia: Henry Carey Baird & Co.

FOUNDRY WORK: A PRACTICAL GUIDE TO MODERN METHODS OF MOLDING AND CASTING IN IRON, BRONZE AND OTHER METALS, INCLUDING MANY VALUABLE HINTS ON SHOP EQUIPMENT AND MANAGEMENT, USEFUL TABLES, ETC. By W. C. Stimpson. 150 pages. Bound in cloth. Price, $1. Chicago: American School of Correspondence.

ELEMENTARY FORGE PRACTICE. By Lord J. Bakon. 289 pages. Bound in cloth. Price, $1.50. New York: John Wiley & Sons.

MACHINERY FOR REFRIGERATION; BEING SUNDRY OBSERVATIONS WITH REGARD TO THE PRINCIPAL APPLIANCES EMPLOYED IN ICE MAKING AND REFRIGERATION, AND UPON THE LAWS RELATING TO THE EXPANSION AND COMPRESSION OF GASES; WITH DESCRIPTIONS AND ILLUSTRATIONS OF THE LATEST MAKES OF ICE-MAKING AND REFRIGERATING MACHINES. By Norman Selfe. Cloth, $3.50; mor., $4.50. Chicago: Nickerson & Collins Co.

THE METHODS OF TEXTILE CHEMISTRY; BEING THE SYLLABUS OF A LECTURE COURSE ADAPTED FOR USE IN TEXTILE LABORATORIES. By F. Dannerth. 172 pages. 12°. Bound in cloth, $2. New York: John Wiley & Sons.

THE STRUCTURE OF THE WOOL FIBER, AND ITS RELATION TO THE USE OF WOOL FOR TECHNICAL PURPOSES; WITH NUMEROUS COLORED AND OTHER ILLUSTRATIONS. By F. H. Bowman. 495 pages. Bound in cloth. Price, $2.60 net. New York: Macmillan.

DYEING AND CLEANING: A PRACTICAL HANDBOOK. By Frank J. Farrell. 240 pages. 78 illustrations. Bound in cloth. Philadelphia: Lippincott.

HARPER'S HOW TO UNDERSTAND ELECTRICAL WORK; A SIMPLE EXPLANATION OF ELECTRIC LIGHT, HEAT, POWER AND TRACTION IN DAILY LIFE; WITH A DICTIONARY OF ELECTRICAL TERMS PREPARED BY JOS. H. ADAMS, AND MANY ILLUSTRATIONS. By W. H. Onken, Jr., and Jos. B. Baker. 376 pages. Bound in cloth. Price, $1.75.

WATER-POWER ENGINEERING; THE THEORY, INVESTIGATION AND DEVELOPMENT OF WATER POWERS. By Daniel Webster

Mead. 803 pages. Bound in cloth. Price, $6 net. New York: McGraw Publishing Co.

An Elementary Manual of Radiotelegraphy and Radiotelephony for Students and Operators. By Ambrose J. Fleming. 354 pages. Bound in cloth. Price, $2 net. New York: Longmans, Green & Co.

The Temperature-Entrophy Diagram. Second revise and enlarged. By C. W. Berry. 317 pages; figures. 12°. Bound in cloth. Price, $2. New York: John Wiley & Sons.

A Dictionary of Engraving (Particularly of the Modern Commercial Processes), Together with Terms Used in Related Branches, as Electrotyping, Lithography, Advertising, Printing, Art, Photography, Etc., Idiomatic and Technical. By W. H. Baker. Price, 75 cents. Cleveland, Ohio: William H. Baker.

Steam Boilers. By Cecil Hobart Peabody and F. Furber Miller. 442 pages. Bound in cloth. Price, $4. New York: John Wiley & Sons.

A Text-Book of Mechanical Drawing and Elementary Machine Design. By J. Reid and D. Simpson. 451 pages. Bound in cloth. Price, $3. New York: John Wiley & Sons.

A Short History of Pittsburgh. By Harden S. Church. 135 pages. Bound in cloth. Price, $1.25 net. New York: De Vinne Press.

BOOK REVIEWS.

Electric Furnaces: The Production of Heat from Electrical Energy and the Construction of Electric Furnaces. By Wilhelm Borchers, Ph.D., professor at the Institute of Technology at Aachen. Translated by Henry G. Solomon. 224 pages, 282 illustrations. Price, $2.50. New York: Longmans, Green & Co.

This is an English version of Dr. Borchers' German book on electric furnaces and comprises over 200 pages devoted to a general illustrated treatment of many of the electric furnaces which have been described previously in print.

Furnaces are classified in accordance with methods of heat application, comprising "direct resistance heating" (in which the charge is itself the resistor), "indirect resistance heating" (in which the charge is in contact with a special resistor), "direct arc heating," "combined resistance and direct arc heating," "indirect arc heating," to each division of which a chapter is devoted. Other chapters deal with "furnaces arranged for different modes of heating," being chiefly a description of the Borchers experimental furnaces; "the construction of electric furnaces" giving especially details on electrode construction and connections, and "furnace outputs."

The book is well illustrated, there being an average of over one graphic description per page, and it is pleasing to note many departures from the familiar time-worn cuts which have previously been employed in electric-furnace literature.

The chief portion of the book deals with the historical development of electric furnaces rather than with the features of the practical electric furnace of to-day, and the author's obvious intent is to place credit where he himself believes it to be due for the various features of electric furnace design and practice. To this end many references are made to the patent literature. To us it seems that Prof. Borchers occasionally greatly overrates the importance of his own experimental work for the development of the art, as he is led to claim for himself priority of many inventions which are usually attributed to others.

The great industrial usefulness of the electric furnace in its numerous forms would justify the existence of text-books dealing with the present state of the art, and it will be an encouraging sign of electric furnace progress when an authoritative volume shall appear which takes up the design, construction, operation and efficiencies of workable furnaces from the practical engineering point of view.

In this respect the details given in Dr. Borchers' book on electrode construction and connections will be found very useful, although the immense possibilities of artificial graphite are not even noticed. But it can hardly be claimed that this volume presents a complete analytical study, since power factors of alternating-current furnaces are not mentioned, constructive materials are not discussed from the standpoint of electric and heat conductivity and refractory qualities, and costs of furnaces and furnace operation are not dealt with. Nevertheless, many experimental details given in Dr. Borchers' book will be found useful, representing first-hand information, based on the author's own experience. In this fact rests the chief value of the book. As an analytical study of electric furnaces it is inferior to Prof. Stansfield's work. But as long as we have not yet all the information that is useful or even necessary, collected in a single volume, Borchers' book deserves a place at the side of Moissan's and Stansfield's works in the library of electrochemists.

The translation is, in general, satisfactory. But there are small slips or ambiguities which give the style at times somewhat of a sloppy appearance. Thus on page 1: "The heat developed must be equivalent to the work EC, if during the passage of a current of C amperes through a length of conductor the e.m.f. consumed be E volts." EC is not work, but power, and the sentence should read: "The heat developed per second must be equivalent to the power EC." On page 2 it is said to be self-evident that "in conductors of the same material, both the resistance *and the heat produced* increase with increasing length. . . ." But this is true for the heat produced only if the current is maintained constant; it would be quite different with constant impressed e.m.f. On page 3 it should be clearly stated that the four temperatures of wires calculated are those which the conductors would have after t seconds if no heat was conducted away or radiated. And so on. We also noticed some misprints. The statement on page 211 that a kilogram is approximately 1½ lb. (instead of 2.2 lb.) is a bad example.

If the translator would adopt FitzGerald's term "resistor" for the material or substance which offers a resistance to the passage of an electric current, many passages in the book would become smoother reading. Since Mr. FitzGerald proposed this term in our columns three years ago, it has been quite generaliy adopted in this country.

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Principles and Practice of Agricultural Analyses. Vol. II: Fertilizers and Insecticides. By Harvey W. Wiley, A.M., Ph.D. 650 pages. Price, $4.50 net. Easton, Pa.: Chemical Publishing Co.

It is a pleasure to take up this book, and Dr. Wiley has certainly placed the chemical world in general, and agricultural chemists in particular, under great obligations. The work has been brought quite up to date; a great part of the material relating to the occurrence and analysis of ammonia, nitrous and nitric acid, printed in Vol. I, has been rewritten and transferred to this volume, thus making the first and second revised volumes about the same size. The paper devoted to the description and manufacture of calcium cyanamide and the fixation of atmospheric nitrogen, will be of interest to our electrical friends in Niagara Falls, where a plant for the manufacture of calcium cyanamide is now being built.

The book is divided into four parts; part one dealing with methods of sampling, statistics, composition and analysis of phosphates; part two with the nitrogen in fertilizers, drainage waters, the utilization of the nitrogen of the air and methods of determining nitrogen and nitric acid; part three with potash in fertilizers, organic sources of potash and method of analysis and determination of potash; and part four with the classification and description of miscellaneous fertilizers, insecticides and fungicides.

Very complete references are given and the index is good.